CERTA-TN: Consolidation of Integral System Test Experimental Databases for Reactor Thermal-Hydraulic Safety Analysis

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European Thematic Network

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Final Report

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Foreword

The European Commission, in line with its constituent provisions, promotes cooperation in research and technological development among the Member States through multi-annual Framework Programs. The Framework Programme 5 (FP5) which covers the period 1998-2002, has two distinct parts:

- the European Community (EC) Framework Programme covering research, technological development and demonstration and training activities of generic nature, and

- the European Atomic Energy Community (EAEC) or Euratom Framework Programme dedicated to research and training activities in the nuclear sector.

Both the EC and the Euratom Framework Programs are complemented by underpinning or horizontal research and development activities aimed at supporting needs and requirements of interest to all research areas.

The overall Framework Programme is mainly implemented by Calls for Proposals launched by the Specific Programs (seven in the EC part and one in the Euratom part):

Thematic Programmes

- Quality of Life and Management of Living Resources (LIFE Quality)
- User-friendly Information Society (IST)
- Competitive and Sustainable Growth (GROWTH)
- Energy, Environment and Sustainable Development (EESD)
- Nuclear Energy (FP5-Euratom)

Horizontal Programmes

- Confirming the International Role of Community Research (INCO 2)
- romotion of Innovation and Encouragement of SME Participation (INNOVATION-SME)
- Improving Human Research Potential and Socio-economic Knowledge Base (IMPROVING)

As a general rule all legal entities established in the Member States and as, appropriate, in the Associated States are eligible for financial support provided that proposed activities are favorably evaluated and approved.

This report has been produced as part of the work-package of the CERTA Thematic Network established under the Euratom Nuclear Energy Specific Programme which aims at exploiting the full potential of nuclear energy in a sustainable manner by making related technologies safer and economically competitive.

The specific objectives of CERTA is to consolidate the reactor safety experimental databases acquired in European thermal-hydraulic integral system effect test facilities in order to ensure their preservation and user-friendly access/retrieve using modern web-based information technologies.

Acknowledgement

The CERTA Thematic Network has been established within and is supported by the European Commission Euratom Framework Programme 5 (1998-2002); Key Action: Nuclear Fission. It assembles experts from ten major European reactor safety research organisations involved in the experimental investigation of accidents and transients in water cooled reactors.

The partners of the CERTA-TN consortium appreciate the support provided by the European Commission in providing the framework for an effective collaboration at the pan-European level in the adoption of modern information technologies to preserve/archive and access/retrieve water reactor safety integral system effect thermal-hydraulic databases.

The principal authors of this report would like to acknowledge the contribution from all staff members of the experimental and/or analytical teams of the participating research organisations who have provided or participated in collating the information contained in this report.

1 Rationales of the CERTA Thematic Network

1.1 Introduction

The CERTA Thematic Network (CERTA-TN) has been established and is partially funded under the Euratom Framework Programme 5 (Euratom-FP5) which implements in the period 1998-2002, the provisions of the European Atomic Energy Community Treaty originally signed in 1957 in order to promote research and training activities for the peaceful use of nuclear energy.

The safety evaluation of existing reactors and, in perspective, of evolutionary or innova/tive reactor concepts, is generally supported by a wide spectrum of experimental and analytical efforts aimed at 1) the acquisition of representative experimental databases in integral system effect and/or separate effect test facilities and 2) the development of computer codes in order to provide realistic predictions of system and/or component behaviour under accident conditions.

It is retained that there are continuing requirements to access integral system experimental databases to sustain reactor safety analysis activities as well as to support the refinement of models and numerical schemes of current as well as advanced reactor safety analysis codes. An additional element to consider is the capital investment required for the establishment and conduction of such large scale experimental programs which in the presence of current economic constraints facing the nuclear research community will be certainly difficult to revisit [1].

The extent to which the existing reactor safety experimental databases are preserved and can be eventually accessed and/or recovered is thus an issue often debated in the nuclear community. In addition to the loss of related skilled resources, a compounding problem is the rapid advancement of computer hardware and software technology which is making several of the storage methods obsolete and as such access to the data in some cases practically impaired.

The CERTAT-TN **rationales** are thus based on shared perceived needs to provide a consolidated framework for the preservation and for the provision of user-friendly access/retrieve capabilities of the reactor safety thermal-hydraulic databases acquired in European integral system effect test facilities. The CERTAT-TN innovative aspect is the exploitation of advanced hardware and software computer technologies (e.g., web-based techniques) to ensure a distributed repository of reactor safety experimental databases allowing also the storage and retrieval of supporting information such as test facility design drawings and test data analysis reports.

The **programmatic objectives** of the CERTA Thematic Network are thus primarily aimed at providing a consolidated framework for the preservation of the integral system experimental databases for reactor thermal-hydraulic safety analysis acquired in the context of the research programs carried out by European institutional and industrial research organizations. The **specific objectives** include:

- assessment of current practices adopted within the CERTA-TN participating organizations in the storage of the reactor safety thermal-hydraulic data bases and in the maintenance of the related documentation;

- definition of optimized data storage and access/retrieve requirements for the verification and validation of system codes used in reactor thermal-hydraulic safety analysis;

- establishment of a user-friendly, web-based distributed informatic platform based on modern information technologies and provision of a demonstration package for remote data access and retrieve.

As structured, the CERTA-TN includes experimental programs and databases relevant to reactors in operation within the EU member countries as well as to reactors in operation within the Central and Eastern-European Countries and the New Independent States.

It is retained that in addition to inherent technical/scientific added values, the CERTA-TN will promote the establishment of a common safety culture at the pan-European level representing also a precursory network of centres of excellence in the context of the envisaged European Research Area.

1.2 Reactor Safety Research Rationales

Following the construction of the first European nuclear power reactor in 1956 (i.e., the 50 MWe Magnox type GCR Calder Hall 1 at Seascale in Cumbria, UK), the nuclear power industry has developed across several European countries. The greatest expansion of the commercial European power industry occurred in the period 1970-1980 in response to international crises that encouraged many countries to diversify energy supplies lessening reliance on conventional fuels such as oil.

The Three Mile Island accident in 1979 and the Chernobyl disaster in 1986, however, as well as safety problems related to the treatment and disposal of radioactive waste, have had adverse consequences on further deployment of additional nuclear capacity in many countries. Nevertheless, nuclear power continues to represent an important contribution to the overall European and international energy economy and, as such, related safety concerns need to be properly addressed on a continuing basis.

There is a wide consensus of opinions on the fact that continued operation of nuclear installations has to evolve within an adequate safety context to prevent potential adverse consequences to the general population and to the environment. Accident prevention is a widely accepted prerequisite for ensuring the safe operation of nuclear installations. The fundamental principles of accident prevention are the quantification of the safety margins in both operational and anticipated accident conditions and the adherence to the prevailing regulatory framework and best practices guidelines.

Within this context, a general international consensus of opinions emerged in the early 70s on the need to provide reliable methodologies for a realistic estimate of the performance of the engineered safety systems, notably the emergency-core-cooling system (ECCS), during the course of design basis loss-of-coolant accidents (LOCAs) or of any other anticipated abnormal sequence. Emphasis was placed mainly on deterministic experimental and analytical methodologies supported, as appropriate, by probabilistic risk assessment studies with the aim to:

- acquire representative experimental databases in scaled integral system effect and/or separate effect test facilities in order to provide reference information for the fundamental understanding of major physical phenomenologies governing plant operation and the evolution of prospected accidents and transients;

- provide safety analysis capabilities through the development of safety analysis computer codes in order to realistically predict system and/or component behaviour in operational or accident conditions and quantify the related safety margins as well as the effectiveness of emergency operating procedures and eventual accident management strategies.

Since the experimental data acquired in scaled test facilities cannot be directly extrapolated to the full size plant due to scale-dependent distortions and simulation constraints, it is maintained that reactor safety analysis has to rely mainly on computational evidence provided by validated safety analysis codes. However, in order to verify that computer codes can accurately model the specified safety cases, a significant code validation effort against representative experimental data is required. Also, the code predictive capabilities have to be proven to be scale independent so that the full-size plant behavior can be predicted with an acceptable confidence.

1.3 European Experimental Programs

A considerable amount of resources has been devoted at the international level during the past three-decades in order to plan and conduct experimental programs for the generation of reference thermal-hydraulic databases to support code development and assessment, Figure 1. Reactor safety thermal-hydraulic research has been traditionally based on:

- separate-effect experiments to investigate specific phenomena and develop/validate related analytical models;
- integral-system-effect experiments to simulate reactor system response and develop/validate and assess reactor safety analysis codes.

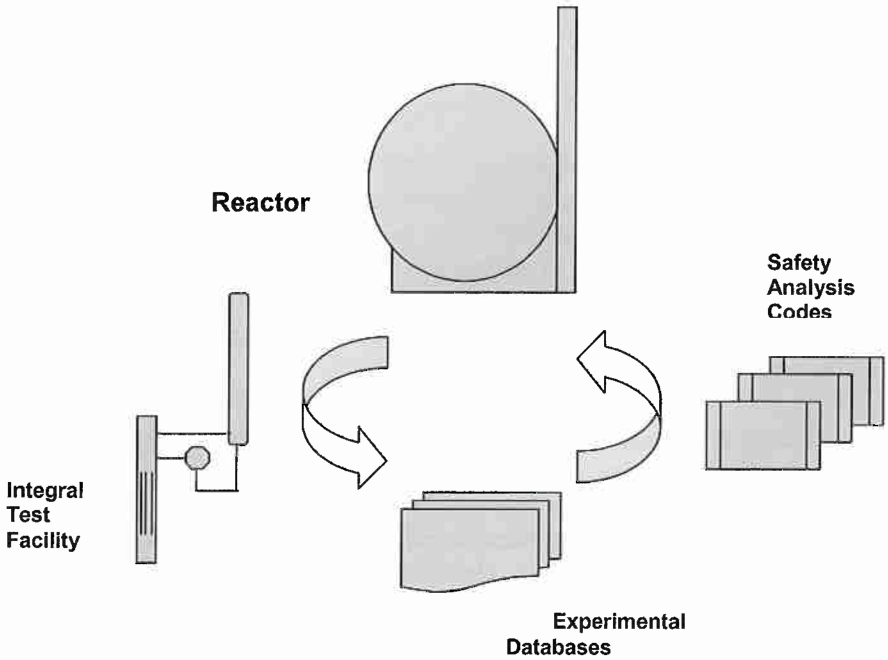


Fig. 1 Idealization of Scaling Process

Research into reactor safety integral-system-effect thermal-hydraulics originated in the early '70s in the US with the definition and execution of experimental programs in the Loss-of-Fluid-Test (LOFT) facility and in the Semiscale test facility. Similar research activities were also initiated in Japan with the establishment of the ROSA and later the Large Scale Test Facility (LSTF) experimental programs.

Referring to the European context, integral-system-effect thermal-hydraulic investigations initiated in Germany with the construction and operation of the Primärkreisläufe (PKL-I) test facility in the late '70s; other major European experimental programs which followed thereafter and are partners in the CERTA-TN project are listed below. Experimental programs have also been promoted by research organisations in Russia to address VVER reactor types thermal-hydraulic safety issues such (e.g., the Integral System Test Facility (ITF) and the Large Scale Test Facility PSB experimental programmes).

In view of the transnational aspects related to nuclear reactor safety and taking into account contingent safety issues concerning the EU enlargement agenda, the network includes experimental programs and data bases relevant to a) reactors in operation within the EU member countries as well as to b) reactors in operation within the Central and Eastern-European Countries (CEEC) and the New Independent States (NIS).

The acquired experimental databases have been instrumental in the development/assessment of reactor safety thermal-hydraulic system codes for western-type pressurized and boiling water reactors (PWRs and BWRs) such as CATHARE, ATHLET, RELAP, TRAC, etc., as well as for safety codes specifically developed for the analysis of accident and transients in eastern-type pressurized water reactors (VVER) such as DYNAMICA, TECH, etc.

Table 1-European LWR Integral System Test Experimental Programs

PROGRAMME	DENOMINATION	ORGANISATION	COUNTRY
PKL	PrimaerKreisLäufe	Framatome ANP (Siemens/KWU)	Germany
BETHSY	Boucle d'Etudes Thermohydraulique Système	CEA (Grenoble)	France
SPES	Simulatore PWR per Esperienze di Sicurezza	SIET - Piacenza	Italy
LOBI	Loop Off-normal Behavior Investigations	JRC - Ispra	EC
UPTF	Upper Plenum Test Facility	Framatome ANP (Siemens/KWU)	Germany
PIPER 1	BWR Simulator	Pisa University	Italy
PACTEL	VVER Simulator	VTT Energy /Lappeenranta University of Technology (LTKK)	Finland
PMK	VVER Simulator	KFKI	Hungary
FIX-II	BWR Simulator	Studsvik	Sweden
PANDA	Passive Decay Heat Removal and Depressurization Test Facility	PSI - Villigen	Switzerland

The reactor safety experimental databases accumulated to date in European integral system test facilities provide a set of fundamental information for the safe operation of existing reactors and for the development and assessment of related computational methodologies.

Currently, experimental databases are maintained in variety of forms and format (e.g., paper support, tapes, diskettes, CDs). In addition to data storage and accessibility concerns, other issues must also be considered in order to ensure widespread or selected access and use of the data. Sufficient information on facility design and instrumentation as well as on operational characteristics are required to construct the code input model for pre- and post-test prediction calculations.

The CERTAT-TN innovative aspect is the exploitation of advanced hardware and software computer technologies (e.g., web-based techniques) to ensure a distributed repository of reactor safety experimental databases allowing also the storage and retrieval of supporting information such as test facility design drawings and test data analysis reports.

1.4 Design and Scaling Considerations

Reactor safety integral system test facilities are normally designed to preserve geometrical similarity with the reference reactor system. Generally, all main reactor components and the engineered safety systems are represented. The main reference accident scenarios are large and small break LOCAs and anticipated transients with and without scram (ATWS).

Referring to a PWR and VVER configurations, the major mechanical components normally include the reactor pressure vessel and downcomer, the core rod bundle simulator, upper and lower plenum, upper head, main coolant piping, pressurizer, steam generators, main coolant pumps, etc. Depending on the specific simulation requirements, the engineered safety systems may include all or a combination of the High Pressure Injection System (HPIS), the Accumulator Injection System (AIS), the Low Pressure Injection System (LPIS), the Auxiliary feedwater System (AFWS) and the Volume Control System (VCS). For a typical BWR configuration there are some special components which need to be simulated such as the steam separator, jet pumps and the depressurization system. A notable characteristic of VVER type reactors is the horizontal Steam Generators.

Major limitations in the design of integral system test facilities are generally given by simulation constraints with respect to the nuclear heat source which, for practical safety and economic reasons, cannot be easily reproduced in a laboratory scale installation (LOFT being an exception) and by economic constraints which generally pose limitation in the size of the installation as well as maximum nominal power and pressure.

Each integral system test facility is scaled to preserve, insofar as possible or practical, similarity of thermal-hydraulic behaviour with respect to the reference plant. As general scaling principle, a power-to-volume scaling criterion is adopted in the design of the facility to ensure the preservation of the primary fluid specific power input.

To meet this widely accepted scaling requirement, the test facility is designed to preserve on the basis of the selected power to volume scaling ratio, the following parameters:

- core power to system volume ratio;
- volumes and relative volumes of individual components;
- rupture size to primary system volume ratio;
- pressure drop and temperature distribution along main flow paths;
- height and elevation of major components;
- core and steam generators heat transfer surfaces.

The elevation of the major components is maintained whenever possible at full height to preserve gravitational driving forces especially in slow transients with the primary inventory partially depleted. The core and steam generators heat transfer and flow areas are matched to the scale factor.

A major exception to the general geometric scaling concept is the design of the reactor pressure vessel model annular downcomer that in some cases is simulated by an external pipe. Strict adherence to the power-to-volume scale factor would result in some cases in unacceptably high wall frictional pressure losses in the primary loop pipework due to long and small size diameter pipes.

Any scaled test facility has inherent distortions with respect to the reference plant that may impair the typicality of some test data results. The major simulation constraint is the lack of nuclear feedback of a nuclear core that is generally simulated with an electrically heated rod bundle.

The power-to-volume scaling concept results in a design that exhibits a basically one-dimensional thermal-hydraulic response, components high surface area to fluid volume ratio and large metal mass to fluid volume ratio. The structural stored energy and system heat losses are important contributors to distortions in those components, such as the reactor pressure vessel and steam generator downcomers, where the coupling between wall heat transfer and fluid flow is at time dominant.

System heat losses may significantly influence primary as well as secondary side energy removal especially during the long-term phase of a small break LOCA or intact circuit fault simulations. Test facilities exhibit larger heat losses, relatively to the reference plant due to design (surface to volume ratio of fluid retaining components) and operation constraints (main coolant pump seal and instrumentation cooling); typically, heat losses in a full size plant account for about 0.05% of the nominal thermal power whereas in a test facility can be in the order of 1.5% when not properly compensated with insulation and trace heaters.

All in all, the experimental results acquired in scaled integral system test facilities cannot be directly extrapolated to full-size plants; they provide, however, a reference data base for the understanding of governing thermal-hydraulic phenomenologies and for the development of analytical models and the assessment of system codes used in reactor safety analysis.

Table 2 - Major Design and Scaling Parameters of Integral Test Facilities

Facility	Scaling Factor		Core Power	Pressure	Loops	Heater Rods**
	Volume	Elevation	(MWth)	(MPa)	(#)	(#)
PKL I + II	134	1	1.5	4.0	1+1+1(2)	340
PKL III	145	1	2.5	4.5	1+1+1+1	340
LOBI	700	1	5.4	16.0	1+ 1(3)	64
BETHSY	100	1	3.0	15.5	1+1+1	428
UPTF	1	1	steam injection	2.2	4	193 dummy
SPES	420	1	30	15.5	1+1+1	97
PWR*	1	1	3800	15.0-15.8	1+1+1 +1	c. 51000
PIPER ONE	2200	1	0.28	7.4	-	16
FIX-II	770	1	6.1	9.0	1 +(3)	36
PANDA	40	1	1.5	1	-	690
BWR*	1	1	3800	7.8-9.0	24	c. 52000
PMK	2070	1	2.0	1.60	6	18
PACTEL	305	1	1	8.0	3	144
VVER-440*	1	1	1375	12.5	6	c. 44000

* typical (#) lumped loops ** electrical heating

2 Current Practices in the Maintenance of European LWR Integral System Test Thermal-Hydraulic Databases

2.1 Status of Experimental Programs

Within the European context, institutional and industrial research organisations initiated research into reactor safety thermal-hydraulics in the late '70s with the PKL, LOBI and FIX test facilities. The major research effort was accrued in the '80s with the construction and commissioning of a number of integral system test facilities such as BETHSY, SPES, UPTF, PIPERONE, and PMK. It continued with a limited effort in the '90s with the commissioning of the PACTEL and PANDA test facilities.

To date, some of the reported experimental programmes have been terminated and several test facilities dismantled; e.g., LOBI, BETHSY, UPTF and FIX-II. Some of the test facilities are still in operation such as PKL, PACTEL, PMK and PANDA, SPES and PIPERONE are in stand-by conditions. The Table below provides a synopsis on the status of the experimental programs providing also an indication of the related capital investment [2].

Table 3 - European LWR Integral System Test Facilities (status: October 2001)

No.	PROGRAM	REFERENCE REACTOR SYSTEM	YEARS OF OPERATION	Kv	STATUS	PARTIAL COST OF THE PROJECT (*) Hard/Software(+)	OVERALL RESEARCH COST (M€*)
	PKL I		1977-1981				
	PKL II		1981-1986				
	PKL III A		1986-1989				
1	PKL III B	KWU-4loop PWR	1989-1992	145	In operation	-	50
	PKL III C		1992-1995				
	PKL III D		1995-1999				
	PKL III E		since 2000				
2	BETHSY	Framatome PWR	1986-1998	100	In stand by(°)	15/38	53
	SPES 1	W-312 PWR	1988-1991	427		8/5	
3	SPES 2	W-AP600	1991-1994	395	In stand by(°)	2/3	18.4
	SPES 99	2 loop PWR	1999			0.2/0.2	
4	LOBI MOD1 LOBI MOD2	KWU-4loop PWR	1979-1982 1982-1991	712	Dismantled	50/90	140
5	UPTF 2D/3D UPTF TRAM	KWU-4loop PWR	1985-1990 1991-1995	1	Dismantled	-	215
6	PIPER-ONE	GE-BWR SBWR	1987-1990 1990-1997	2200	In stand by(°)	1.8/2.2	4
7	PACTEL	VVER-440	since 1990	305	In operation	2.1/2	4.1
8	PMK	VVER-440	1986-1990 since 1991	2070	In operation	1/0.8	1.8
9	FIX-II	ASEA-ATOM BWR	1978-1986	777	Dismantled	2.5/3.5	6
10	PANDA	GE-SBWR ESBWR SWR1000	since 1995	40	In stand by(#)		10

(*) M€ related to year 2000
(°) needs major funds to be operated
(#) facility is presently going through modifications for the EU-5^{th} Framework Program projects TEMPEST and NACUSP.
(+) human resources included

Recently, the Senior Group of Experts on Safety Research (SESAR) assembled by the Committee on the Safety of Nuclear Installations (CSNI) of the Organisation for Economic Cooperation and Development - Nuclear Safety Agency Committee (OECD-NEA), reviewed the research being carried out in the field of reactor safety identifying future requirements and priorities. With respect to water cooled reactor integral system thermal-hydraulic research, SESAR recommended co-operative research programmes in some of the test facilities still in operation and the preservation of the acquired experimental databases focusing, as appropriate, on an international project in this field.

The invested financial resources in the CERTA-TN related research programmes is in the order of 450 M€ related to the year 2000 value. The capital investment is thus rather substantial and needs to be preserved in the context of current and prospected financial constraints that can make future research programmes in this field highly unlikely.

2.2 Test Facility Description

This section contains a short description of the European integral system test facilities included in the CERTA-TN project.

2.2.1 PKL – PrimaerKreisLäufe Test Facility
(Framatome ANP, Germany)

The PKL test facility (Figure 6.1) was originally designed to investigate the effectiveness of emergency core cooling systems following large and small break LOCAs (PKL I and II). In order to cover also the wide field of accident transients including the experimental verification of cooldown procedures, the test facility was enlarged and equipped with new components and subsystems in 1986/87 (PKL III). These modifications were performed on the basis of a Siemens/KWU 4-loop reactor of the 1300 MWe class. The PKL III test facility simulates the entire primary side with 4 loops and the essential part of the secondary side. All elevations of the test facility correspond to actual reactor dimensions. The overall volume and power scaling factor is 1:145.

The reactor core is modeled by a bundle of 314 electrically heated rods with a total power of 2.5 MW corresponding to 10 % of the scaled nominal power. The RPV downcomer is modeled as an annulus in the upper region and continues as two stand pipes connected to the lower plenum. This configuration permits a symmetrical connection of the 4 cold legs to the RPV. This means , that the requirement for identical piping lengths and hence recirculation period is fulfilled. This configuration allows, among others, to investigate the individual effects of multiple system failures. Experiments on the behavior of a 3-loop (2-loop) plant can also be conducted by simply isolating one (two) loop(s). Each of the primary side loops contains active coolant pumps, which are equipped with speed controllers to enable any pump characteristics to be simulated. The four fully scaled steam generators are equipped with prototypical tubing (diameter, wall thickness, differing lengths) and tube sheet.

The maximum operating pressure of the PKL facility is 45 bar on the primary side and 60 bar on the secondary side. This allows the simulation over a wide temperature range. Extensive analyses show that even with steam voiding in the system the major phenomena can be modeled accurately in qualitative terms, and with only minor deviations in quantitative terms. Counterpart tests with LOBI and LSTF have provided additional information on the validity of the extrapolation of PKL results to higher pressures.

PKL is also equipped with all relevant engineered safety and operational systems on the primary and secondary side. On the primary side four independent high- and low pressure safety injection systems connected to both the hot and cold legs, the residual heat removal system, 8 accumulators, the pressurizer pressure control system and the chemical and volume control system are simulated. On the secondary side the feed water system, the emergency feedwater system and the main steam lines with all control features of the original systems are modeled. For the realistic simulation of the secondary side bleed-and-feed procedures, special care was taken to correctly model the feedwater lines and the feedwater tank with respect to the volume (1:145), the elevations (1:1) and the friction losses (1:1). All these features allow the simulation of a wide spectrum of accident scenarios, the interaction between the primary and secondary side in combination with various safety and operational systems.

The extensive instrumentation with more than 1300 measuring points guarantees optimum use of the test results. Besides conventional measurements (temperature, pressure, etc.) two-phase flow measurements are also used. In addition, for the current test series PKL IIIE special measurement devices for the detection of boron concentration have been installed.

2.2.2 BETHSY - Boucle d'Etudes Thermohydraulique Systeme (CEA, France)

The BETHSY integral test facility (Figure 6.2) has been designed for the analysis of PWR accident situations controlled by automatic circuits and/or operator action. The facility is designed to model a 3 loop PWR. The main objectives of the BETHSY test programme are to contribute to:

- improve the knowledge of the physical phenomena which occur during PWR accidents, particularly when two-phase flow takes place in the PCS;
- assess safety computer codes, especially the advanced code CATHARE;
- validate the physical assumptions of event and state oriented Emergency Operating Procedures.

BETHSY is equipped with all circuits and systems which are likely to play a role during an accident transient. The core bypass is represented and the external downcomer is linked to the upper head through calibrated orifices in order to represent the downcomer to upper head spray nozzle. The external downcomer has a trefoil-shaped device at the top to better simulate the mixing between the loops.

BETHSY has the same number of loops as the reference reactor. The inner diameter of all the piping is 118 mm as given by the Froude criterion applied to the hot legs, and the elevation of the horizontal part of the crossover leg is preserved.

The primary coolant pumps are capable of delivering the nominal flow rate but have also a controllable rotation speed in order to both get the right energy distribution when necessary in the PCS and to simulate the pump coast-down. The elevation of the pump diffuser with respect to the cold leg is preserved.

The pressurizer is connected either to an intact or to the broken loop and is equipped with on-off and proportional heaters, the normal and the auxiliary spray systems, a relief circuit with adjustable setpoints and relief capacity.

Each of the three steam generators includes 34 U-tubes of the same radial dimensions and height, stepping as in the reference steam generator and so arranged that the hydraulic diameter of the secondary side is preserved and the tube lane is true to scale. A trace heating system is provided for steady state and low transient tests.

2.2.3 SPES - Simulatore PWR per Esperienze di Sicurezza (SIET, Italy)

The SPES integral test facility (Figure 6.3) permits a simulation of a 3 loop PWR system in those events that follow the reduction of the normal cooling capacity in case of loss-of-coolant accidents or multiple failures.

The volume scaling of the facility is 1:427 and includes a full length electrically-heated power channel, full scale elevations and three complete primary loops. This last item is one of the most important features because SPES can simulate the same number of loops as the actual plant and it is able to study those accidents where loss of loop balance can occur.

Full electrical power is available to the core simulator. Downcomer is designed as an external tube for the several advantages of this choice in particular concerning the pressure drop reduction.

The general scaling criteria concern the preservation, in any SPES component of the following parameters:

- fluid thermodynamic conditions (pressure and enthalpy);
- power-to-volume ratio;
- power-to-flow rate ratio;
- transit time of the fluid;
- heat flux.

Further scaling criteria were applied to design the individual SPES components; these particular criteria allow to correctly simulate the thermal hydraulic phenomena that have more influence on the behaviour of each component. For example, in components with vertical fluid flow the elevations have been preserved, to obtain a good reproduction of the natural circulation phenomena; on the contrary, in components where the prevailing flow direction is horizontal, the Froude number conservation has been imposed to preserve, as much as possible, the flow pattern transitions in horizontal tubes. The particular scaling criteria for the main components of the SPES loop are:

The vessel downcomer geometry is tubular, to obtain the minimum pressure drop distortion compatible with the volumetric criterion and the elevation preservation. The elevation is very important in small break transients because they influence among other the loop seal clearing phenomenon. Therefore, two different loop seal geometries will be available; the first one will preserve volume and elevation and the second one will preserve volume and Froude number.

The pressure drop preservation has not been included neither in the general nor in the particular scaling criteria; however, the scaling criteria used for the SPES design produce a reasonable pressure drop distribution. Indeed, in the "vertical" components (like the core and the steam generators) the SPES hydraulic diameters are usually very similar to the PWR; therefore, the pressure drop reproduction is quite good, as the fluid velocity, density and flow length are preserved according to the scaling criteria for these components. On the contrary, in the "horizontal" components (like hot and cold legs), the hydraulic diameters are strongly reduced (by a factor of about ten). Nevertheless, this effect is well compensated by a reduction in fluid velocity and flow length, due to the application of the volume and Froude number scaling criteria.

2.2.4 LOBI – Loop Off-normal Behavior Investigations
(EC-JRC Ispra, Italy)

The LOBI test facility (Figure 6.4) is a full-power high-pressure integral system test facility representing an approximately 1 : 700 scale model of a 4-loop, 1300 MWe PWR. It incorporates the essential features of a typical PWR primary and secondary cooling system. The test facility was commissioned in December 1979 and was operated until June 1982 in the MOD1 configuration for the investigation of large break LOCAs; it was then extensively modified into the MOD2 configuration which was operated from April 1984 to June 1991 for the characterization of phenomenologies relevant to small break LOCAs and Special Transients in PWRs.

The test facility comprises two primary loops, the intact and the broken loop which represent respectively three loops and one loop of the reference PWR. Each primary loop contains a main coolant circulation pump and a steam generator. The simulated core consists of an

electrically heated rod bundle arranged in a square matrix inside the pressure vessel model. The primary cooling system operates at normal PWR conditions; approximately 15.8 MPa and 294 - 326° C pressure and temperature, respectively.
Heat is removed from the primary loops by the secondary cooling system which contains a condenser and a cooler, the main feedwater pump, and the auxiliary feedwater system, Figure 2. Normal operating conditions of the secondary cooling system are 210° C feedwater temperature and 6.45 MPa pressure.

The reactor pressure vessel model comprises the pressure vessel, the core barrel tube and the core simulator. Lower plenum, upper plenum, the annular downcomer and the externally mounted upper head simulator are additional major components of the overall pressure vessel assembly. The reactor core is simulated by an electrically heated rod bundle consisting of 64 rods arranged in an 8x8 square matrix inside the flow shroud; heater rod bundle dimensions are reactor typical. The heater rods are directly heated hollow tubes (material 1.4948 DIN 17007) and the rod wall thickness within the heated length is varied in 5 steps to achieve a chopped cosine shaped axial power distribution. Nine grid spacers of original design are placed along the heated length; five additional spacers are mounted in the upper unheated part of the rod bundle. Ceramic segments are arranged inside the core barrel tube forming a square flow shroud which extends over the heated length region of the rod bundle.

The LOBI test facility contains two shell and inverted U-tube type steam generators having a geometrical configuration similar to that of the reference plant In the MOD1 configuration, the steam generators were designed to preserve heat transfer capabilities without proper simulation of secondary side fluid distribution. In the MOD2 configuration, the steam generators were designed with the aim to better represent thermal-hydraulic phenomenologies of interest in intact circuit faults.

The LOBI-MOD2 emergency-core-cooling system (ECCS) comprises the high pressure injection system (HPIS) and the accumulator injection system (AIS). As required, the low pressure injection system (LPIS) could also be simulated. Provisions are made for cold leg, hot leg or combined cold and hot leg ECC injection in both primary loops. In the MOD1 version of the test facility only the accumulator system was simulated. Additional safety injection systems consist of the Volume Control System (VCS) and of the Auxiliary Feedwater System (AFWS).

The measurement system comprised a total of about 470 measurement channels which allowed the measurement of all relevant thermal-hydraulic quantities at the boundaries (inlet and outlet) of each major primary and secondary system loop component and within the reactor pressure vessel model and steam generators. A process control system allowed the simulation of time or pressure dependent parameters such as core decay heat release, main coolant pump hydraulic behavior and safety injection flow rates. A fast running data acquisition system complemented the experimental installation.

2.2.5 UPTF – Upper Plenum Test Facility
(Framatome ANP, Germany)

The UPTF (Figure 6.5) was a geometrical full-scale mock-up of the primary system of a 4-loop 1300-MWe Siemens/KWU PWR. The test pressure vessel and its internals, the upper and lower plenum and the downcomer as well as piping of the loops were identical to those at the Grafenrheinfeld nuclear power plant in Germany. Plant components needed in UPTF to establish reactor-specific conditions, such as the reactor core, reactor coolant pumps, steam generator and containment were simulated. The core is simulated with controlled injection of steam and water supplied from external sources. The core simulator consists of 17 inlet pipes for both water and steam as well as 193 water-steam mixers to feed 193 dummy fuel elements. The core simulator is divided into 17 zones each of which has separate steam and water injection valves (0.7 s opening time) such that core radial peaking and steam and water flow rates can be set to represent core conditions of interest. Total flow capabilities are 360 kg/s steam and 2000 kg/s water.

The loops are equipped with flow restrictors to simulate the reactor coolant pumps and with steam/water separators representing the steam generators. The containment simulator is designed to reproduce the containment pressure history for a LOCA in the reactor being simulated. For the UPTF TRAM program an original surge line and a pressurizer were installed.

The break size and location could be simulated in the broken loop. The emergency core cooling injection systems at the UPTF were configurated to simulate the various ECC injection modes, such as hot leg, upper plenum, cold leg, downcomer or combined hot and cold leg injection of different ECC systems of German and US/Japan PWRs. The evaporation and entrainment of emergency core coolant during an accident transient were simulated by injected steam and water via nozzles located beneath the 193 dummy fuel assemblies (core simulator). To ensure real primary inventory and the correct core liquid level during the experiment water was drained from the lower plenum equivalent to the mass of injected core simulator steam and water.

The maximum operating pressure was 2 MPa and the simulated decay power was 150 MW (4%). Large mass flows of saturated steam (up to about 750 kg/s) were required when running the tests. This quantity can only be supplied by a power plant, using in addition a large steam storage tank. For this reason, the high-capacity conventional power station GKM was selected as site. GKM supplies 85 kg/s steam at 530 °C and approximately 2 MPa which is cooled to about 220 °C before it enters UPTF. This steam is utilised for heating the test facility and steam storage tank as well as for pressurising the fluid in accumulators, hot water storage tank and containment simulator. Saturated water is supplied to the core simulator from a hot water storage tank, in which the water is heated to approximately 185°C and stored under steam pressure of approximately 2 MPa.

UPTF was operated between 1985 and 1995, the test facility has been dismantled in the meantime.

2.2.6 PIPERONE – BWR Simulator
(University of Pisa, Italy)

The PIPER-ONE apparatus (Figure 6.6) is an integral test facility designed for reproducing the behavior of BWR in thermal hydraulic transients, dominated by gravity forces. The General Electric (GE) BWR-6 plant, equipped with 624 fuel bundles was assumed as reference for the first test carried-out in the PIPER-ONE facility, chosen by OECD-CSNI as ISP 21. This plant was thereafter used as reference for all the subsequent LOCA tests.

The apparatus is constituted by a loop, which reproduces the vessel of the BWR-6 plant. The ECCS simulators (LPCI/CS, HPCI/CS), the systems simulating ADS, SRV and steam line and the blow-down line complete the facility. The heated bundle consists of 16 (4x4) indirectly heated electrical rods, whose height, pitch and diameter are the same as in the reference plant. The maximum available power is about 320 kW, corresponding to 25% of scaled full power of the reference BWR.

The volume scaling factor is about 1/2200, while the core cell geometry and the piezometric heads acting on the lower core support plate are the same in the model and in the reference plant. The one-dimensionality as well as the overall simplicity of the apparatus has been taken into consideration in order to have clear conditions for code nodalization thus avoiding confusing simulation assumptions.

The instrumentation system has features consistent with the fundamental philosophy of the facility design. The data acquisition system can record 128 signals, with a frequency of up to 10 Hz for each signal. After the series of LOCA tests, the facility hardware was modified by inserting the IC loop, which can operate at the same pressure of the main circuit. The main component of the isolation condenser loop is a heat exchanger, consisting of a couple of flanges, that support 12 pipes, 22 mm outer diameter and 0.4 m long; it is immersed in a tank of 1 cubic meter in volume, containing stagnant water, located at the 4th floor of the PIPER-ONE service structure.

The heat exchanger is connected at the top with the steam dome and at the bottom with the lower plenum of the main loop, respectively. Its operation principle is the following: when the reactor is shut-down and isolated due to a special transient (e.g. LOFW or turbine trip), the opening of the IC line valves allows the removal of decay heat by natural circulation; the primary steam is condensed by IC and the liquid returns to the reactor, maintaining coolant inventory inside the vessel. The isolation condenser loop is instrumented with a turbine flow-meter and a differential pressure transducer on the hot side; about 30 thermocouples in various positions of the IC and of the pool, as shown in Fig. 2, complete the IC system. Hardware restrictions preclude the possibility to have a system correctly scaled with respect to those provided for the new generation nuclear reactors, particularly the GE SBWR.

2.2.7 PACTEL – VVER Simulator
(VTT Energy and LTKK, Finland)

PACTEL (Figure 6.7) is a volumetrically scaled (1:305) facility designed to model the thermal-hydraulic behavior of VVER-440 type pressurized water reactors used in Finland. These reactors have several unique features that differ from other PWR designs. PACTEL simulates all major components and systems of the reference PWR. The primary pumps were installed in the beginning of 1993.

The maximum operating pressures on the primary and secondary sides are 8 MPa and 4.6 MPa respectively, while the corresponding values in VVER-440 are 12.3 MPa and 4.6 MPa. The reactor vessel is simulated with a U-tube construction including separate downcomer and core sections. The core itself consists of 144 full-height, electrically heated fuel rod simulators with a chopped cosine axial power distribution with a peaking factor of 1.4. The maximum total power output of 1 MW, 20% of scaled full power. The fuel rod pitch (12.2 mm) and diameter (9.1 mm) are identical with those of the reference reactor. The rods are divided into three roughly triangular-shaped parallel channels representing the intersection of the comers of three hexagonal VVER rod bundles.

Component heights and relative elevations correspond to those of the full-scale reactor to match the natural circulation gravitational heads in the reference system. The hot and cold leg elevations of the reference plant have been maintained, including the loop seals. The hot leg loop seals are a result of the steam generator locations, which are at roughly the same elevation as the hot leg connections to the upper plenum. The hot and cold leg connections to the steam generators are at the bottom of each collector, and a U-shaped pipe must be used. The cold leg loop seals are result from the elevation difference between the inlets and outlets of the reactor coolant pumps, just like in other PWRs.

To preserve flow regime transitions in the horizontal sections of the loop seals under two-phase flow conditions the Froude number has been applied to select the diameter and length of the hot and cold legs. As a result, the total hot and cold leg pipe lengths were shortened by almost a factor of two compared to the reference plant. The pipe cross-sectional area was increased to preserve the volumetric scaling factor used for the reminder of the facility and preserve the time scale for emergency transport from the heat source to the sinks.

Three coolant loops with double capacity steam generators are used to model the six loops of the reference power plant. The U-tube diameters of the PACTEL steam generators correspond to those of the full-scale models, but the overall height of the steam generators is smaller. The scaled heat exchange area of the tubes is preserved. The horizontal orientation of these steam generators is one of the unique features of the VVER design. One consequence of this geometry is a reduced driving head for natural circulation. Another notable feature is the relatively large secondary side water inventory, which tends to slow down the progression of transients.

The PACTEL facility is instrumented with temperature, pressure, differential pressure and flow rate transducers. During an experiment about 600 channels are scanned each second. A network of about 350 thermocouples are used to measure temperatures of the primary and secondary side coolant, heater rod cladding, and various structures. Mass flow rates are measured in the downcomer and cold legs. 45 differential pressure transducers are used to determine the collapsed water levels in the pressurizer, core, and steam generator secondary side in addition to providing complete circuits of differential pressure measurements around each loop. The modern process control system controls the primary and secondary pressure, core power, and emergency cooling systems.

2.2.8 PMK – VVER Simulator
(KFKI, Hungary)

The PMK test facility (Figure 6.8) was designed for investigating plant transients, LOCA accidents, accidents caused by disturbances coming from the secondary circuit and accident sequences in support of accident management.

The PMK-2 is a scaled-down model of the primary- and partly the secondary circuit of the Paks Nuclear Power Plant. Relevant similarity criteria were applied to the design to ensure the similarity in cases of forced circulation, as well as single- and two-phase natural circulation. The design is certainly a compromise between similarity requirements and the investment cost. Due to the importance of the gravitational forces in both single- and two-phase flow the elevation ratio is 1:1, except for the lower plenum and pressurizer.

The six loops of the plant are modeled by a single active loop. The main circulating pump can not be applied to two-phase flow conditions, therefore the pump is accommodated in a by-pass line. Pump is used until the end of pump coast-down, then it is valved off from the loop. Main characteristics of the facility are given below.

The core model consists of a 19-rod bundle with axially and radially uniform power distribution. The flow channel is made of ceramic material. However, the facility is made of stainless steel except for steam generator housing, the inner surface of which is covered by a thin stainless steel layer .The non-heated part of fuel elements are made of copper.

Heat transfer tubes between hot and cold collectors of the horizontal steam generator have a special shape. For the injection of feedwater at proper elevation a tube with perforation is used. The piping of the main circulation line allows the right modeling of both the hot and cold leg loop seals. To keep the Froude number, the inner diameter is 46 mm. Piston pumps are applied to HPIS and LPIS with nominal flow rate. The four hydro-accumulators are modelled by two vessels (SIT-1 and SIT-2).

2.2.9 FIX II – BWR Simulator
(Studsvik, Sweden)

The FIX-II test facility (Figure 6.9) is volume to power scaled as 1:777 to the Oskarshamn 2 external pump BWR. The four pump loops of the reactor are modelled by one larger and one smaller loop with RCPs representing three and one of the reactor loops respectively. Maximum operating pressure was 9.0 MPa, and maximum bundle power was 6.1 MW.

The pressure vessel contains a 36-rod, full length bundle and a spray condenser at the top to allow steady state operation at full power. The fuel rod simulators are directly heated and filled with compacted magnesiumoxide to improve the simulation of stored heat. The axial heat flux distribution is non-uniform with a downwards peaked cosine-shape. The downcomer, bypass channel and guide tube volumes are represented by external piping. The bypass channel could be heated by a separate power supply. A separate cooling loop provides control of the heat loss from the pressure vessel surrounding the fuel bundle.

Simulation of guillotine breaks as well as split breaks of various sizes can be made by means of quick opening valves in the small RC-loop. The facility is equipped with ADS simulation, but no ECC injection systems are included. The two RC pumps have speed control, the large one with an advanced thyrister system for fast mass flow transients.

The FIX test facility has also been used to investigate response of pump trips and MSIV closures in internal pump reactors. These experiments were conducted with a blinded broken loop and coast-down characteristics simulating low pump inertia. In another test period the loop control system were modified in order to facilitate simulation of pressure increase transients with fast positive power ramps (steam line closure without bypass). The design of the FIX-II loop was preceded by extensive scaling calculations and considerations using the GOBLIN BWR code (property of Westinghouse Atom). For the primary system a volume-to-power scaling to Oskarshamn 2 BWR was applied. Mass fluxes in core and in main piping were retained at steady-state conditions. Also pressure drops in parts important for LOCA simulations were designed to be the same as in the reactor. For practical reasons the loop differs from the ideal scaling of the reactor in some respects. Sensitivity studies of the effect of these deviations were carried out in phase 1 of the FIX-II project. The major scaling problems can be summarised as in the following.

Smaller heated to unheated perimeter in the FIX-II 36-rod bundle than in an actual 64-rod bundle and heat transfer through the fuel bundle box larger at steady-state and at beginning of LOCA transient, thereafter probably reversed since the heat energy stored in structures is larger than in the reactor relative to the volume occupied by the fluid.

A comparatively large fraction of the downcomer channel comprised a horizontal part since this-was placed outside the main test section. Different CCFL characteristics occur for the channel inlet which in FIX-II comprised eight small holes compared to one circular hole in the reactor bundle, although the pressure drop was the same; L/D-effects are impossible to scale preserving the volume scaling and full heated length simultaneously.

The steam dome volume was relatively large since it in FIX-II also constituted a spray condenser to facilitate, full power (6 MW) steady state operation.

2.2.10 PANDA – Passive Decay Heat Removal and Depressurisation Test Facility (PSI, Switzerland)

PANDA (Figure 6.10) is a scaled thermal-hydraulic test facility for investigating passive decay heat removal system for the next generation of LWR. Six cylindrical pressure vessels represent the Gravity Driven Cooling System (GDCS), the Reactor Pressure Vessel (RPV), Drywell (DW) and Wetwell (WW); four pools open to the atmosphere contain three Passive Containment Coolers (PCC) and one Isolation Condenser (IC). Both DW and WW are simulated by two vessels: the two DW vessels are connected by a large diameter pipe, the WW has two large interconnecting lines, the first in the gas space and the second connecting the suppression pools.

The vessels, pools and condensers are interconnected by system lines. This arrangement allows for investigation of three-dimensional effects (such as the distribution of steam and non-condensable gases and mixing within the containment), and provide flexibility to investigate a variety of system design and passive decay heat removal concepts.

After a detailed scaling analysis, power and volumes were scaled 1:40, while elevations, pressure and pressure drops were scaled 1:1. The RPV provides steam produced by electrical heaters (installed power 1.5MW) and maximum pressure of 10 bar can be reached in the PANDA facility. The facility is instrumented with over 500 sensors. Prototypical fluids under prototypical thermodynamic conditions were used in all tests, except that the nitrogen filling the DW has been substituted by air, and the injection of helium simulated the release of hydrogen in the case of a severe accident. Axial distributions of temperatures and non-condensable concentrations in the vessels can be obtained from thermocouple, pressure, and a limited number of oxygen (air) probe measurements.

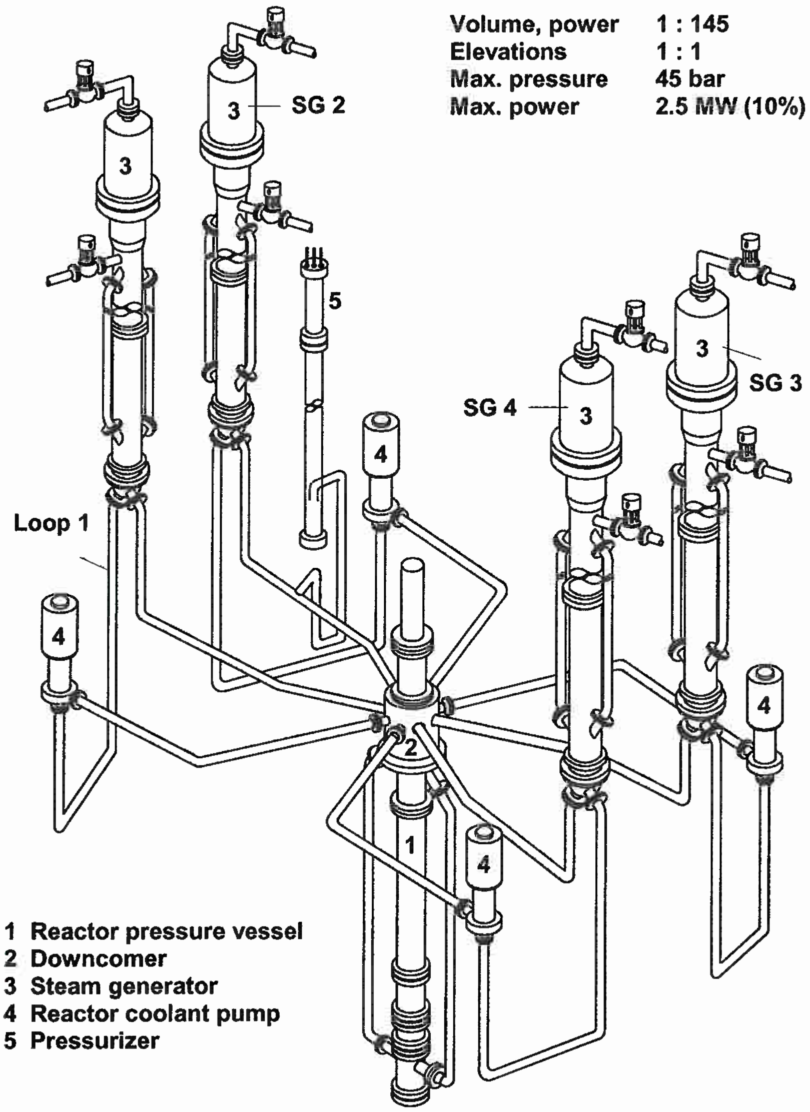


Fig. 2 – PKL III Test Facility

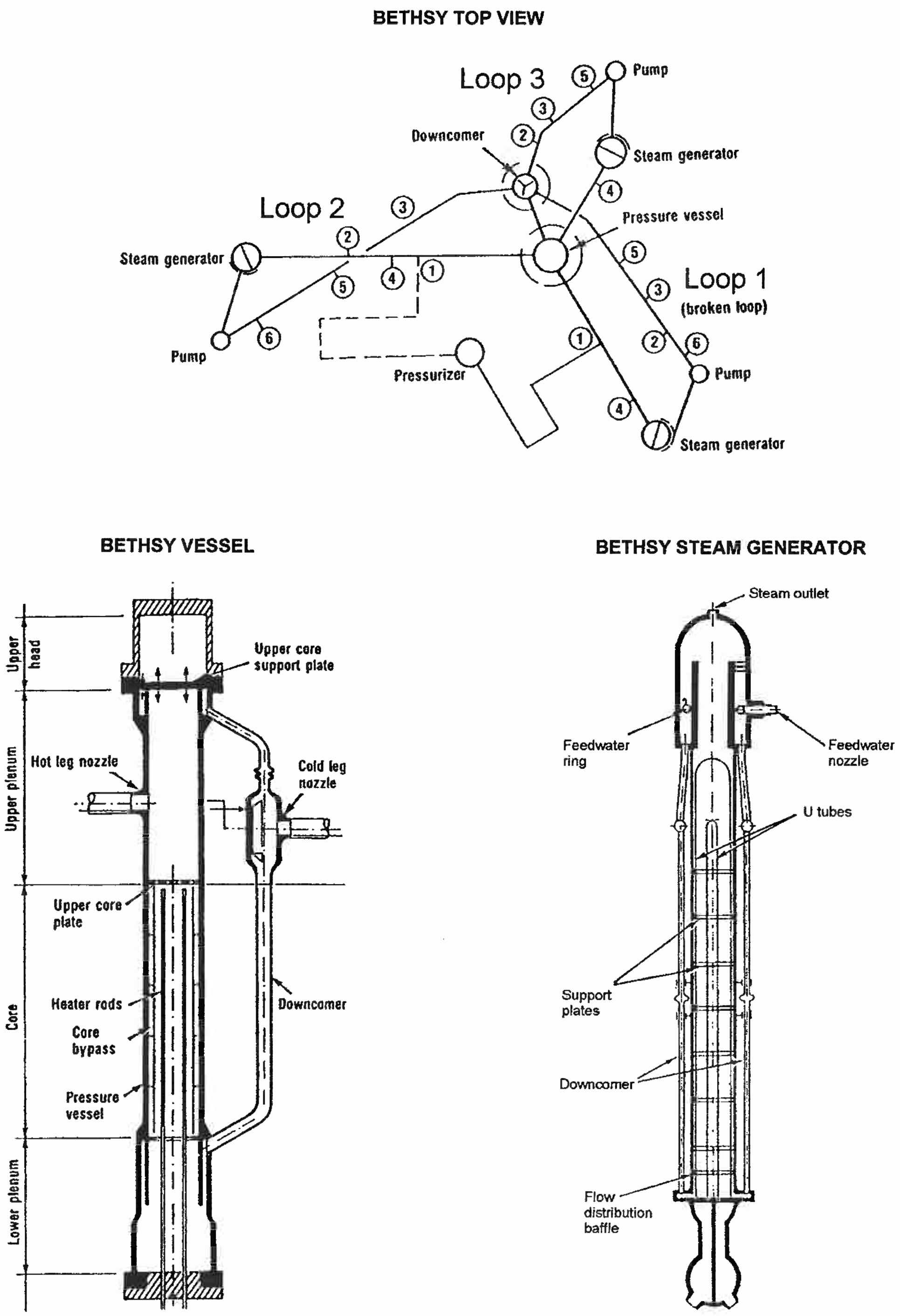


Fig. 3 – BETHSY Test Facility

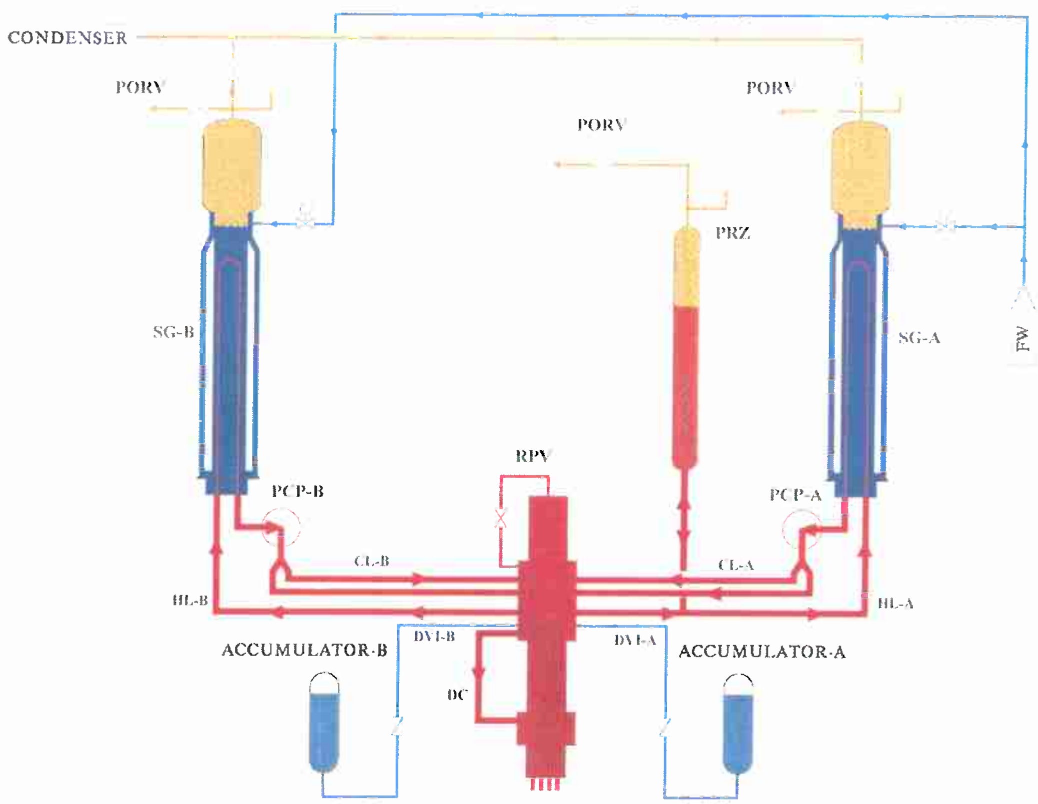


Fig. 4 – SPES 99 Test Facility

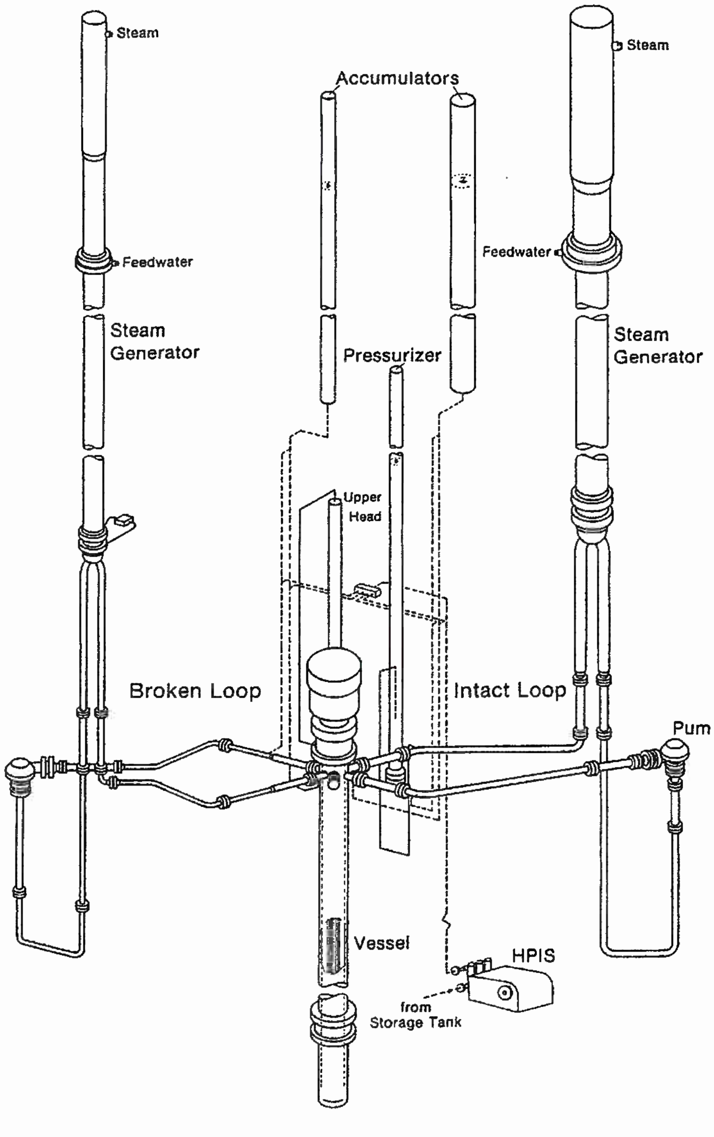
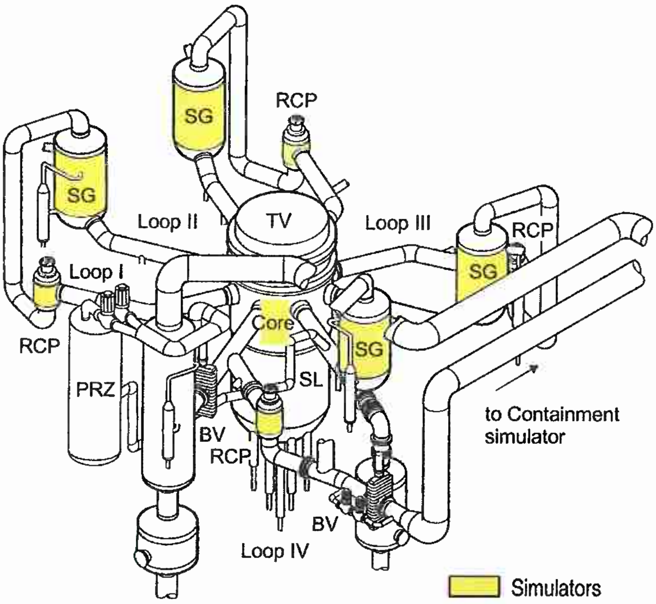


Fig. 5 - LOBI-MOD2 Test Facility



- 4-Loop Test Facility
- Full-scale mock-up of the primary system of a 1300-MW Siemens PWR
- Max. operating pressure: 2 MPa
- Max. operating temperature: 212°C
- Simulated decay power: 150 MW (4%)
- Core simulation by means of controlled steam and water injection
- Simulation of variable size of breaks in hot and cold leg

TV	Test vessel	SG	Steam generator
RCP	Reactor coolant pump	BV	Break valve
PRZ	Pressurizer	SL	Surgeline

Fig. 6 - UPTF Test Facility

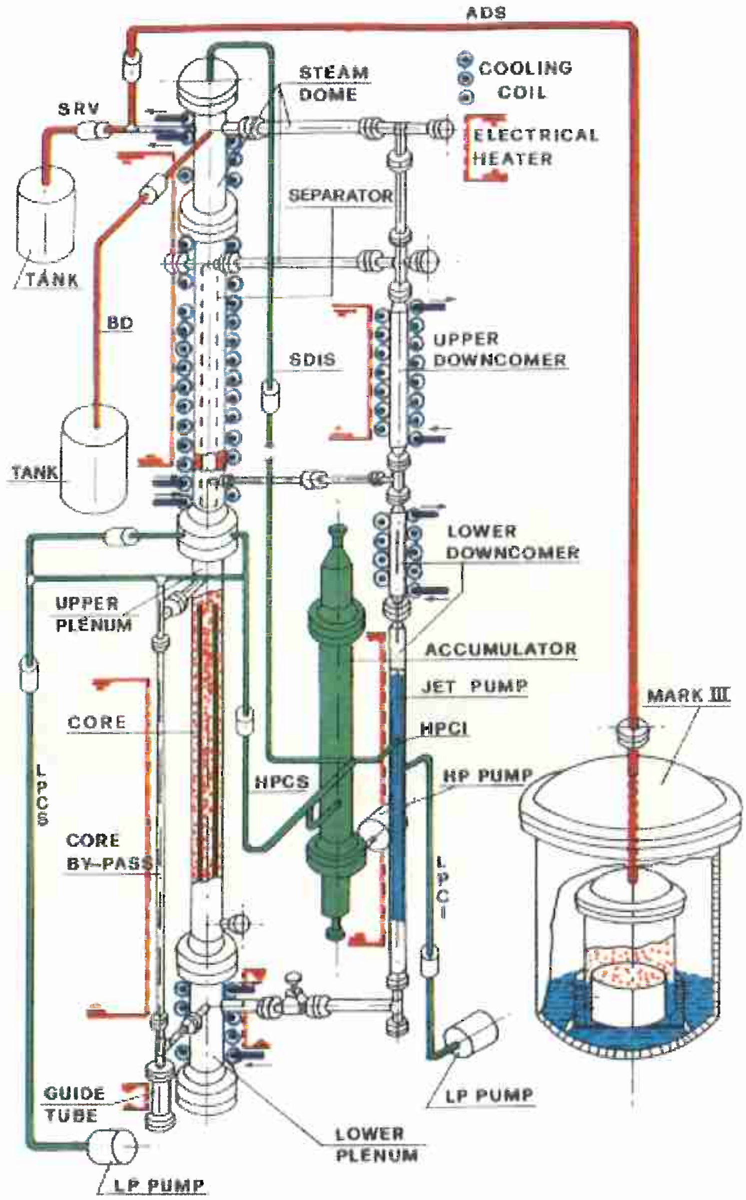


Fig. 7 - PIPER-ONE Test Facility

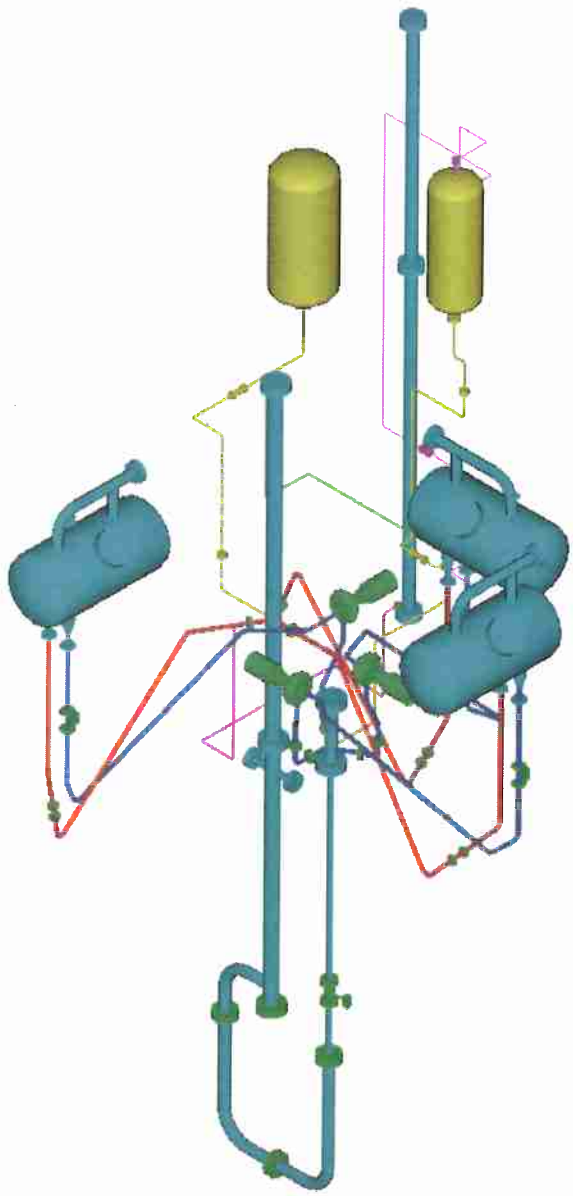


Fig. 8 - PACTEL Test Facility

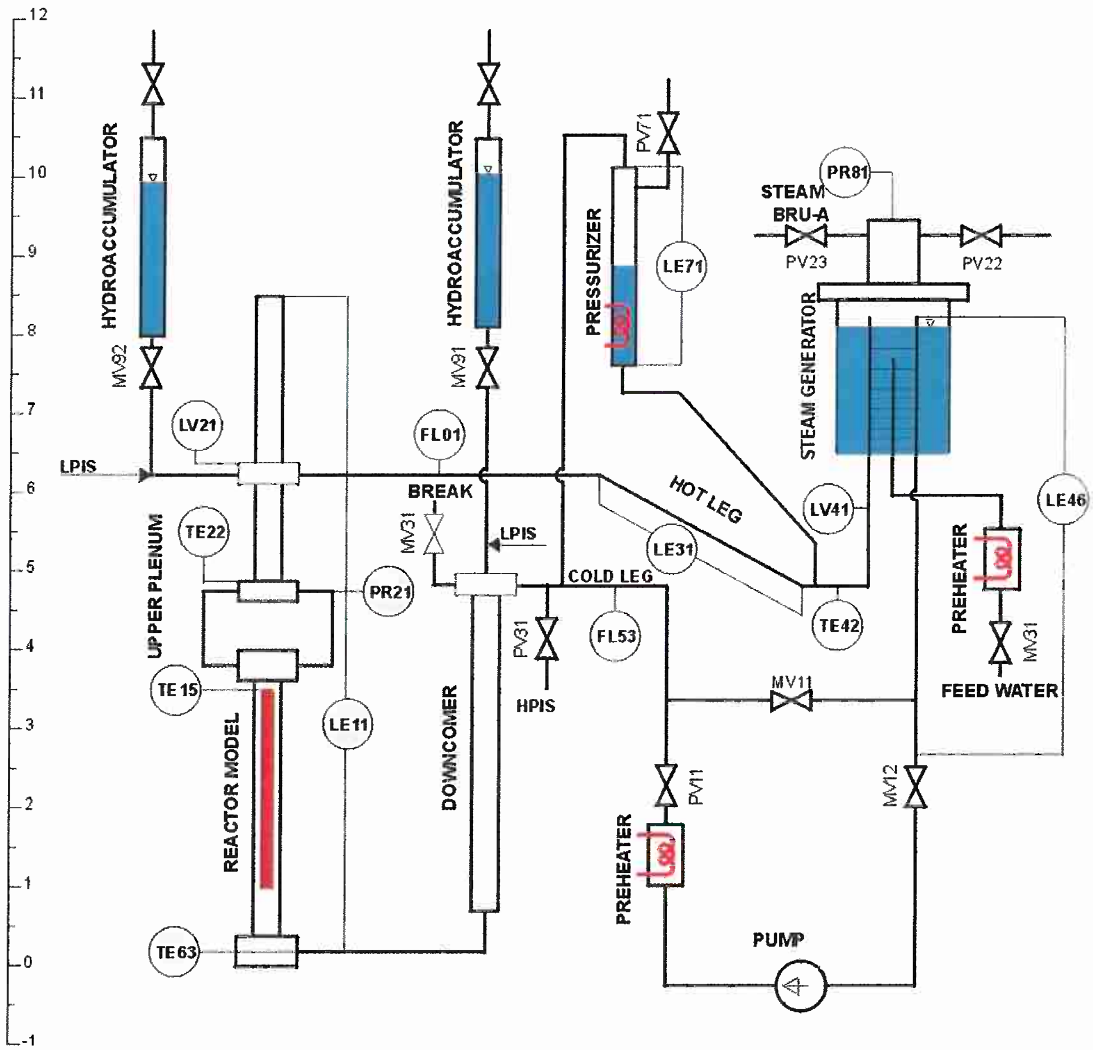


Fig. 9 - PMK Test Facility

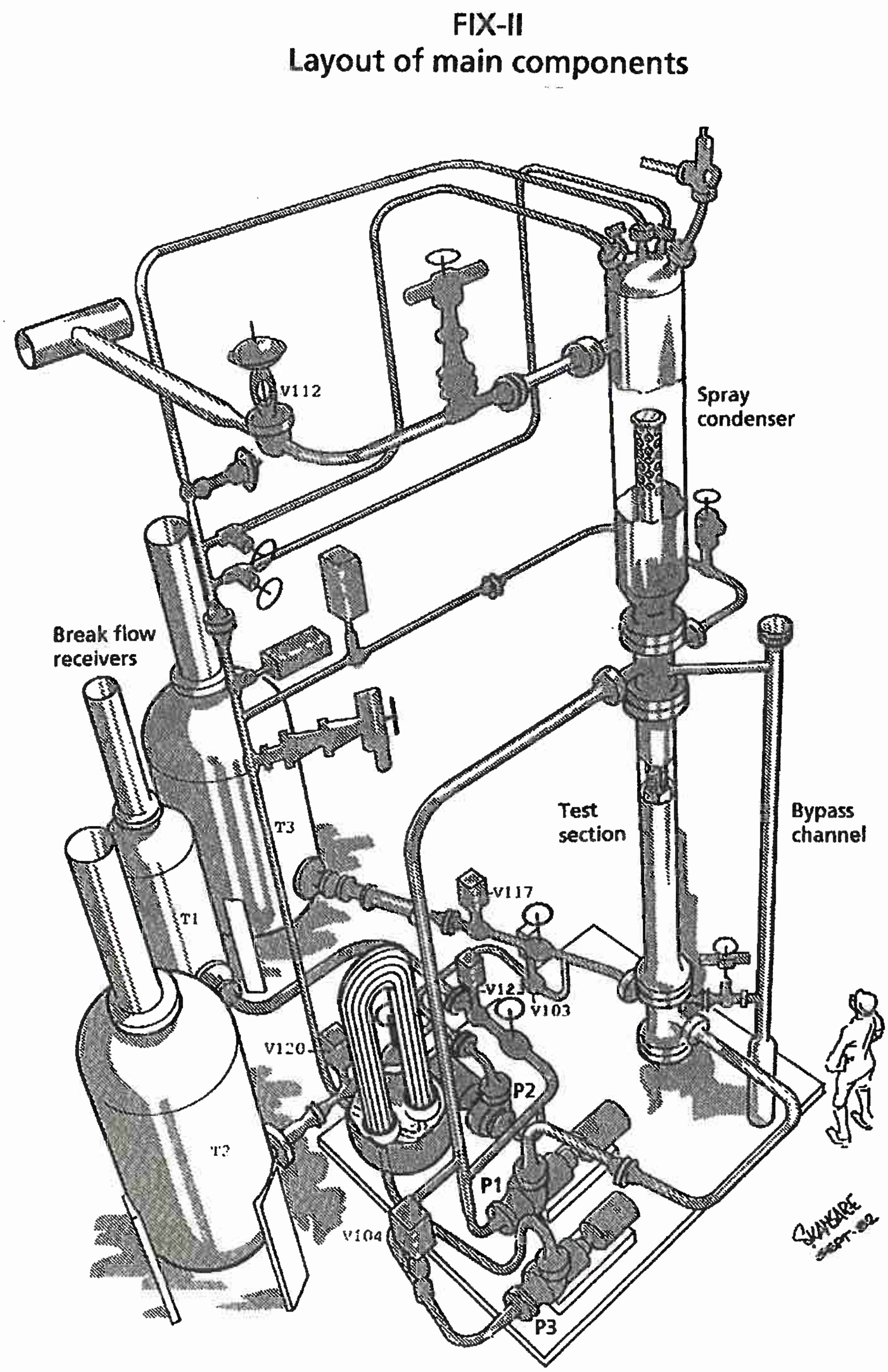
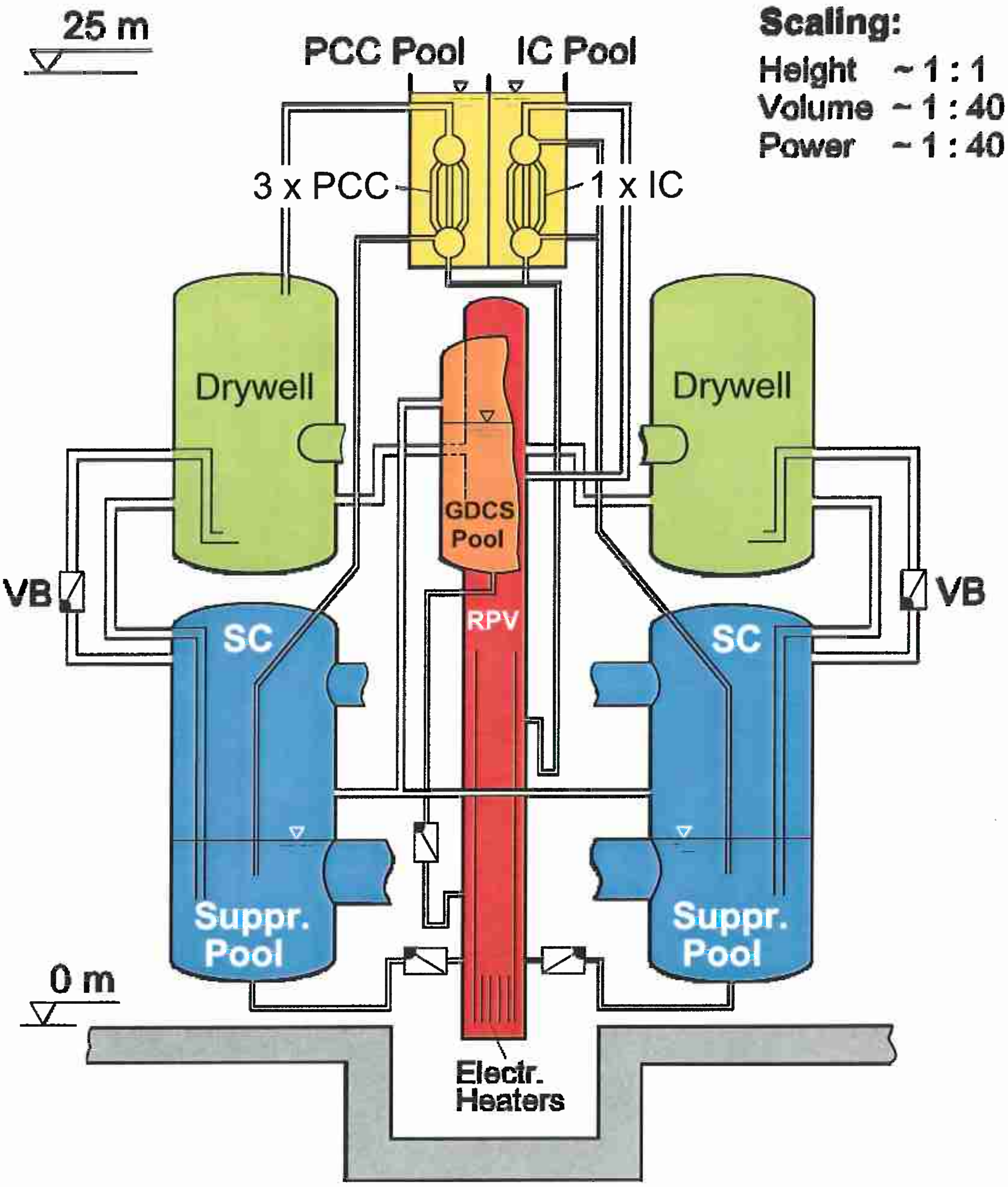


Fig. 10 - FIX-II Test Facility



PANDA Test Facility
ESBWR Configuration

Fig. 11 - PANDA Test Facility

2.3 Experimental Results and Test Matrices

This section summarises the status of the experimental test matrices acquired in the test facilities subject matter of this report. Emphasis is placed on collating information on current data preservation practices and data format including support medium. Since test data analysis reports is a prerequisite in order to ensure an efficient use of the data, information on type and eventual reference of existing reports is also provided. A short outlook of each research programme major results is also provided.

The experimental databases acquired in the reported experimental programmes cover a wide range of reactor accident conditions and reactor reference system configuration. It includes large and small break LOCAs, anticipated transients with and without scram, emergency operating procedures (EOP) and accident management (AM) strategies.

Dedicated test runs have been performed in several of the test facilities to investigated specific phenomenologies such natural circulation heath transport mechanisms, steam generator heath transfer and heath transport degradation. In addition test facility characterisation experiments have been conducted in some cases to provide information on non-prototypical phenomenologies such system heath losses and pressure drops which are important to account for in code simulation.

A short outlook of each research programme major results is a provided as introductory remarks to the experimental test matrices reported in the attached Tables from 7.1 to 7.28.

2.3.1 PKL Test Matrices

Since 1977 experiments to investigate the thermal hydraulic system behaviour of a PWR following postulated accidents have been carried out in the PKL test facility. Results obtained in tests simulating large-break LOCAs (including the end-of-blowdown and reflood phase) showed the efficiency of the emergency core cooling systems even in the case of reduced availability. Subsequent tests dealing with small break LOCAs demonstrated the advantages of automatically initiated countermeasures as specified by Framatome ANP (formerly Siemens/KWU).

The subject of the following PKL III program, started in 1986, has been the investigation of so called accident transients. While the first test series within PKL III, covered design-basis accidents and the verification/optimization of cooldown procedures detailed in the operational manuals, the main interest was then focused on beyond-design-basis accidents (such as total loss of feedwater) and the experimental verification of Accident-Management (AM) procedures. Concerning the latter mentioned topic, it was demonstrated that in particular the secondary side bleed-and-feed is a very effective method for removing decay heat without contaminating the containment. All experiments performed up to now showed the large safety margins of Siemens/KWU PWRs.

The current test program PKL III E is focused on topics of current interest such as boron dilution events that may occur after small break LOCA scenarios. These investigations are performed as part of an international OECD program started in April 2001.

The PKL test results have been used for the validation of thermal hydraulic system codes concerning reactor safety analyses such as RELAP5 and ATHLET, for preparation and verification of procedures described in the operational manuals and for answering questions of current interest arisen by licensing authorities. In conjunction with the complementary UPTF (Upper Plenum Test Facility), the interaction between these both facilities and the reactor safety analysis codes finally have been leading to a deep insight of accident sequences.

The test results of PKL I and PKL II are documented only in final reports. The major test objectives and initial and boundary conditions of the PKL III (A, B, C, D) performed test runs are shown in Tables from 7.1 to 7.6. The experimental data are only available with the agreement of all program partners.

2.3.2 BETHSY Test Matrices

The 82 tests performed on the BETHSY facility have allowed, thanks to a systematic work of analysis, to list, to analyze and understand the numerous physical phenomena attached to a PWR in accidental situation.

The following items have been especially characterized : the depressurization phases on both the primary and the secondary sides, the primary mass inventory evolution and the liquid level in the core, the set-up conditions of a natural convection and the transition to film-boiling regime, the efficiency of the different safety injection systems and of the cooling down procedures back to a safety state included the reflooding phase of large break LOCA's, the role played by non-condensable gas particularly within the steam generator U-tubes, the complex situations involving water plugs formation and expulsion or addressing low pressure transient in cold shutdown conditions. Thus, this wide set of tests has made possible to characterize the physical situations encountered during Accident Management and the fundamental parameters on which the state-oriented approach relies.

Attached to each test, a wide documentation is available which includes the experimental data (roughly more than 1200 physical values every second) and different documents which provide exhaustive informations about the test experimental conditions. Among them, one can mention the Detailed Test Plan (PEE) relative to the test preparation, the Quick Look Report (RPE) and the Test Report (RE) which provide all the qualified informations concerning the test carry-out : facility configuration, scenario, initial and boundary conditions, measurements and their uncertainties.

Hereafter is detailed the whole test matrix of the BETHSY Integral Facility, classified in the following categories:

- Accident management test involving event oriented EOP's (Tables 7.7 and 7.8);
- Accident management test involving the physical principles of the state-oriented approach (Table 7.9);
- Accident management test involving the physical pertinency of actions required in the state-oriented EOP's (Table 7.10);
- Characterisation tests of the facility , counterpart test with nuclear plant (Table 7.11);
- Loss of heat removal system (different tests with primary coolant system open or half open, with and without non condensable) (Table 7.12);
- Large break tests (the refill and reflood phases of a large break LOCA are studied under various conditions) (Table7.13).

2.3.3 SPES Test Matrices

The SPES experimental campaign (Table 7.14) has been the first important program performed by Italy in the field of thermal hydraulic studies on a full power full height integral test facility. All the major Italian research institutions and organisations were involved in the program and collaborate with important international bodies in the analysis of the carried out transients. Although the reference reactor (PUN) was never built, the performed experimental campaign was very important (17 participants took part in the ISP 22) for code assessment and allows SIET to hold a position of prominence in the field of performing thermal hydraulic tests. The experience acquired by SIET during the period of SPES experimental program was fundamental for the successful performance in the following Westinghouse campaign on SPES-2 facility.

The SPES2 facility program (Table 7.15) was developed to examine the performance/capability of the AP600 passive safety systems to mitigate the effects of postulated DBEs and to provide useful data for computer code development and validation.

The test matrix , concluded in November 1994, examined passive safety system response for a range of small break LOCAs at different locations on the primary system and on the passive system lines; single steam generator tube ruptures with both passive and active non-safety systems, and a main steam line break transient to demonstrate the capability of passive safety systems for rapid cooldown. Each of the tests has provided detailed experimental results for verification of the capability of the analysis methods to predict the integrated passive safety system behavior. In all tests, the passive safety systems performed as expected and mitigated the simulated accidents with no heatup of the reactor heater rods.

An unique intermediate break LOCA in cold leg test (Table 7.16) was performed on the SPES-99 facility mainly to test the efficiency of the facility after 5 years of inactivity. The execution of the test, showed a good performance of the SPES system but on the other hand showed also some limitations that should be overcome in case of future experimental campaigns. In particular:

The results of the following 4 tests are available in the CSNI data bank: SP-SB-03, SP-SB-04, SP-ST-01 and SP-FW-02.

2.3.4 LOBI Test Matrices

The LOBI Project has represented an effective approach to international collaboration in the field of reactor safety research and development. In addition to inherent technical/scientific merits, the European Community research context in which it has been carried out, has provided an opportunity for a synergy of resources and an independent forum for a systematic flow of communication among experts of EC Member Countries contributing to the enhancement of a common reactor safety culture at the pan-European level.

The LOBI experimental programme (see Table 7.17), has covered a wide spectrum of PWR accident and transients which have included large and small break LOCAs, Anticipated Transients with and without Scram, emergency operating procedures and accident management strategies.

Referring to large break LOCAs, an extensive data base has been acquired which comprehensively covers the high-pressure or blowdown phase and the refill phase of design basis large and intermediate break LOCAs. In this area, LOBI has represented the only European integral system test facility with full pressure and full power simulation capabilities. Unique test results have also been acquired to ascertain the influence of main coolant pump operation mode on overall system behaviour and core thermal response; i.e., DNB and early rewet.

Scaling of the reactor pressure vessel downcomer is a main constraint in the design of integral system test facilities since volume scaling and pressure scaling are conflicting criteria; i.e., a correct volume scaling criteria would result in a narrow downcomer gap width yielding non prototypical high pressure losses, whereas a pressure scaling approach would result in a large downcomer gap width and consequently large non prototypical volumes. Taking this into account two large break LOCA test series have been conducted in LOBI each with a downcomer of different gap width; i.e. 50 mm and 12 mm. Test results have shown a considerable influence of this design parameter on overall system and core thermal response. Valuable information has also been obtained on phase separation effects especially in the horizontal pipework, early DNB, early rewet, effects of break size and location, and differences between various ECC injection modes.

Referring to small break LOCAs and the Special Transients (ST) area, the related LOBI database is very large. Important information has been acquired on important phenomena such as such as local and global mass distribution in the primary and secondary cooling systems, thermal coupling between primary and secondary sides, effectiveness of secondary cooldown, interaction between loop seal formation and clearance and with core uncovery and rewet.

Considering all pre- and post-test calculations performed by the EC Member Countries in addition to those performed in support to LOBI test design and specification, a considerable amount of code verification has been obtained using LOBI test results. Major codes which have benefited from the use of LOBI test data include RELAP, TRAC, DRUFAN, ALMOD, ATHLET and CATHARE.

Two LOBI tests have been used to carry out international standard problem exercises; i.e.; LOBI-PREX and ISP-18. Currently, the data from 19 LOBI tests are freely available to the international nuclear community through the OECD supported code validation matrix.

2.3.5 UPTF Test Matrices

Experiments have been performed in the UPTF between 1985 and 1995. Major objective of the UPTF 2D/3D program was to study multidimensional flow phenomena in the primary system of a PWR during end-of-blowdown, refill and reflood phases following a postulated loss-of-coolant accident with a hot leg or cold leg break considering various ECC injection modes of different ECC systems. Separate effect and integral tests were performed to study phenomena in the upper plenum, across the upper core tie plate, in the downcomer, and in the hot and cold legs of the primary system. Special emphasis was given to:

- Entrainment and de-entrainment processes in the upper plenum,
- Co-current and counter-current two-phase flow phenomena including water break-through in the upper core tie plate region,
- Co-current and counter-current flow and core bypass in the down comer;
- The effect of condensation and mixing processes caused by injection of cold water by the ECC system.

The objective of the subsequent UPTF TRAM program addressed experiments supporting accident management measures in the event of beyond-design-basis accidents and fluid-fluid mixing investigations dealing also with the pressurized thermal-shock behavior of the RPV.

As a main result of the 2D/3D program the effectiveness of various ECC injection concepts was shown. All major questions, concerning the influence multidimensional thermal-hydraulic effects may have on emergency core cooling processes during design basis accidents were answered with the results of the 2D/3D project.

The overall assessment of the TRAM program shows, that the findings from the TRAM program gained a realistic description of accident management transients. It also reveals, that the thermal hydraulic processes, e.g. condensation due to activation of the emergency core cooling system or flow regime development under natural circulation are better understood and can be quantified after the performed tests.

An important objective of the UPTF experiments was to provide data for the development and validation of reactor safety analysis codes, such as RELAP5, ATHLET and TRAC, to determine the effectiveness of various ECC injection concepts under design-basis accident conditions and to answer questions of current interest arisen by licensing authorities. In conjunction with the complementary PKL facility, the interaction between these both facilities and the reactor safety analysis codes finally have been leading to a deep insight of accident sequences.

The results of the following 4 UPTF SET are available in the CSNI data bank: Test 05a; RUN 063; Test 08a; RUN 112; Test 08b; RUN 111; Test 10b; RUN 081.

The major test objectives and initial and boundary conditions of the performed test runs are shown in Tables from 7.18 to 7.20.

2.3.6 PIPER-ONE Test Matrices

The lesson learnt from the PIPER-ONE research programme can be summarized, taking into account scaling phenomena to plant situations, as in the following. Several basic phenomena occur simultaneously during any transient simulation in a complex facility such as PIPER-ONE apparatus. Characterization of these phenomena is difficult because their interaction is not easily identifiable and furthermore not enough is known about boundary conditions. Nevertheless a few situations may be selected to highlight the test apparatus has given relevant information with respect to post CHF heat transfer; de-entrainment at geometric discontinuities, CCFL at core top and bottom, gravity driven reflood, natural circulation, geysering.

The whole instrumentation system of PIPER-ONE was designed, developed and qualified to cope with measurement of two phase density, measurement of mean volume or surface temperatures, evaluation of mass and energy balances.

Since scaling is a crucial aspect in any experimental research in nuclear reactors thermal-hydraulics a counterpart test activity was planned in the framework of the PIPER-ONE research which was based on the design and execution of PO-SB- 7 (ISP 21) test designed to duplicate initial and boundary conditions of experiments already performed in the FIST (GE, US) and ROSA III (JAERI, J) test facilities.

Evaluation of plant scenarios in case of multiple failures showed that even an unforeseen delay of several minutes in the opening of the ADS valves leads to a situation for rod surface temperature which is far below the maximum values provided in plant design. The possible occurrence of unstable conditions is quite different from code predictions. The core spray and the LPCI liquid cool the core even though there is a large break in the lower plenum.

The whole database obtained so far provides information on the wide safety margins in current BWRs for coping with the accident considered (see Table 7.21).

Computer codes were used for pre-test calculations nearly all the performed tests and in some case also a post-test analysis has been completed. The results of the following 3 tests are available in the CSNI data bank: PO-SB-7 (ISP 22), Test PO-LB-1 and Test PO-SD-5A.

2.3.7 PACTEL Test Matrices

The SBLOCA experiments revealed the strong dependence of natural circulation behavior on primary coolant inventory. Flow stagnation occurs near the same inventory regardless of the break size, though the duration is shorter for the largest break. Condensed flow from the steam generators to the downcomer is intermittent for the boiler-condenser mode. The steam generators retain significant amounts of coolant. The amount of water retained in the steam generators influences the core collapsed level, which in turn has a bearing on when the top of the core begins to dry out and overheat. It is clear that significant coolant holdup in the steam generators can shorten the elapsed time to core heat up in the event of a SBLOCA.

There is a significant qualitative difference between natural circulation in VVER and typical PWR geometry at high primary pressure. These include the peak natural circulation mass flow rates which is observed in the single-phase rather than in the two-phase flow regime. In the VVER geometry there is only a modest increase in the driving head associated with two-phase flow. The transition between single and two-phase flow is not smooth in most of the SBLOCA tests. The flow temporarily stagnates when the water level reaches the hot leg entrances and does not resume until the loop seals clear._Highly asymmetric behavior is observed after two-phase flow is established. Typically, two of the loop seals out of three refills after clearing, reducing flow and shifting the burden of energy transport to the third loop.

In small break LOCAs, loop seal refilling occurs for low flow rates because of countercurrent flow in the up-flow side of the hot leg. These findings point to the importance of using a multi-loop facility to investigate flow behavior in a VVER geometry at reduced inventories. There is certainly interdependence between loop seal filling and the accompanying loss of flow in some loops, and the flow characteristics of the remaining loops. It is also conceivable that if the coolant inventory associated with two-phase flow is maintained for a long period, the flow distribution may change as the core decay heat decreases. In particular, flow may be lost in additional loops as the declining steam production rate permits countercurrent flow in the loop seals and the loop seals refill.

At low primary pressures in VVER geometry the flow behavior is closer to the natural circulation observed in a typical PWR geometry. The primary pressure directly influences the swell levels above the core during boiling and the density of the steam produced. These effects indirectly determinate many of the most important thermal hydraulic behaviors in the hot leg. At low primary pressure, a clear maximum natural circulation mass flow rate is in the two-phase mixture flow mode at 80 % coolant inventory and clearly higher than in single-phase natural circulation flow.

Table 7.22 shows the major test objectives of the performed test runs.

2.3.8 PMK Test Matrices

Since the start-up of the facility altogether 48 experiments have been performed for groups of transients as follows (see also Table 7.23): one- and two-phase natural circulation, loss of coolant accidents (LOCA), special plant transients and experiments in support of the accident management (AM) procedures. The results have been used for the validation of thermal-hydraulic system codes like ATHLET, CATHARE and RELAP5 for VVER applications.

The PMK-NVH/PMK-2 facility was used for experiments of four "Standard Problem Exercises" as SPE-1, SPE-2, SPE-3 and SPE-4 of the International Atomic Energy Agency (IAEA) in the time interval of 1985 to 1995 primarily for SBLOCA-type transients. In the time interval of 1996 to 2000 several PHARE projects have been performed with the aim of obtaining additional experimental data to support, among others, the development and qualification of AM measures. Another group of measurements supported further needs of the safety improvements program of the Paks NPP.

A wide range of small- and medium-size LOCA sequences have been studied to assess the performance and effectiveness of ECC systems and to evaluate the thermal-hydraulic safety of the core. Extensive studies have been performed to investigate the one- and two-phase natural circulation, the effect of disturbances coming from the secondary circuit and to validate the effectiveness of accident management measures like bleed and feed. The VVER-specific case, the opening of the SG collector cover was also extensively investigated.

The study of the natural circulation processes is of great importance, because in off-normal plant conditions the heat removal from the reactor occurs by single or two-phase natural circulation. The natural circulation in VVER reactor systems is also affected by the loop seal in the hot leg and the horizontal steam generator. Experiments have been performed to study the conditions of the one-phase natural circulation, to measure the two-phase characteristics at different primary mass inventories, to identify the effect of non-condensable gases on the natural circulation and to measure the coolant inventory in the core when heat transfer crisis occurs. Measurements were performed for the investigation of the possible disturbances of natural circulation in shutdown conditions of the reactor. In VVER systems the heat in these conditions is transferred to the SG by single-phase natural circulation with two loops.

In most of the LOCA experiments the break location was in the cold leg with a wide range of break sizes as 0.5%, 1.0%, 3.5%, 7.4% and 14.8%. The break size 7.4% was selected to study the effect of different ECCS configurations, the AM actions and presence of non-condensable gases. Hot leg break LOCA accidents were studied for 7.4% and 14.8% to compare the results with the relevant cold leg break LOCA cases. In two types of other experiments, as the opening of the pressuriser safety valve and the break of the pressuriser surge line, the location is also in the hot part of the system.

2.3.9 FIX-II Test Matrices

The FIX-II project generated thermal-hydraulic experimental results of high quality. Experimental results with well-known accuracy confirm largely pre-test calculations, and have been valuable for code assessment. The static dryout measurements are in very good agreement with results from other tests with similar geometry and with predictions, e.g. with Becker's dryout correlation.

The results of the LOCA tests are valuable for determination of the effect of break size and break configuration on time to dryout and maximum cladding temperature before turn-around or rewetting. Maximum dryout temperatures over 800 °C were obtained in one case. One important finding was that the highest PCT was not obtained for the 200% guillotine break, but rather for split breaks slightly smaller than 100% of the flow area of a main RC pipe. Core uncovery progress and time for the pressure to decrease below the low pressure ECCS activation value are other important results. Generally, the tests produced many crucial results for governing thermal-hydraulic variables under LOCA conditions.

The pump-trip and transient dryout tests served their purpose for assessment of power operating limits in actual Swedish BWRs. The results, combined with other analyses have formed basis for plant modifications and power upgrading in Swedish BWRs.
All documented experiments are available and suited for assessment of thermal-hydraulic reactor analysis codes. Specifically, LOCA experiment 3025 (see Table 7.24) has been utilized for various code assessments since it was the basis for ISP-15. At Studsvik several other tests have been used for assessment with RELAP5/Mod2. LOCA tests Nos. 3027 and 5061 have been used for contributions to ICAP (International Code Assessment and Applications Program).
The results of the following FIX-II tests (see Table 7.24 to 7.27) are available in the CSNI data bank:

- LOCA experiments Nos. 3025, 3061 and 5052;
- Pump trip experiment No. 2032;
- Transient dryout test No. 6261.

2.3.10 PANDA Test Matrices

Series of transient system tests (Table 7.28) are performed in the PANDA facility to investigate the performance of the passive containment cooling system of the European Simplified Boiling Water Reactor (ESBWR). The main findings are summarized as follows.

The passive containment cooling system (PCCS) showed generally a favorable and robust long-term post LOCA behavior. The PCCs started working even under extreme conditions. The transition period from the gravity driven cooling system (GDCS) injection phase to the PCCS long-term operation phase was successfully demonstrated. Trapped air somewhere in the drywell and released later in the transient did only temporarily reduce the PCCS performance. Helium injected to the drywell later in the transient adversely affects the PCCS performance. This is an issue, which would need more detailed investigations. The operation of the isolation condenser system in parallel with the passive containment cooling system had positive effect on the overall system behavior. Finally, it was demonstrated that the PCCS was still able to remove a remarkable amount of decay heat from the containment after the PCC pool boil-off exceeded the expected inventory loss over the "no operator action period". In summary, one of the test series successfully demonstrated that the passive decay heat removal systems operate as intended under different accident scenarios.

The extensive database will contribute to further improve containment cooling systems and containment design of passive plants and allow for system code assessment in a wide parameter range.

Table 4 - **PKL III A Test matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Siemens
AC: Loop Characterisation Tests					
	AC-1	Jan 88	Steady-state natural circulation at various water inventories on the primary side	CD-ROM; ASCII-Format	U9 312/88/33
	AC-2	Dec 87	Determination of pressure losses	CD-ROM; ASCII-Format	U9 312/88/34
	AC-3	Dec 87	Determination of heat losses	CD-ROM; ASCII-Format	U9 312/88/35
A1: Shutdown with RCPs in Operation					
	A1.1	Mar 88	Cooldown procedure with 2 RCPs and 4 SGs	CD-ROM; ASCII-Format	U9 312/88/55
	A1.1.1	Mar 88	Pressurizer spraying under cold and hot stand-by conditions	CD-ROM; ASCII-Format	U9 312/89/11
	A1.2	May 88	Cooldown procedure with 1 RCP and 1 SG (3 SGs isolated)	CD-ROM; ASCII-Format	U9 312/88/52
	A1.2.1	May 88	Optimization of depressurization of the isolated SG with running RCPs	CD-ROM; ASCII-Format	U9 312/89/10
A2: Loss of Of-Site Power					
	A2.1	Feb 88	Cooldown procedure with 4 SGs under loss of off-site power conditions	CD-ROM; ASCII-Format	U9 312/88/36
	A2.1.1	Feb 88	Emergency feed water supply into an isolated SG (temperature equalization with the primary side)	CD-ROM; ASCII-Format	U9 312/89/3
	A2.1.2	Feb 88	Restart of RCPs after cooldown under loss of off-site power	CD-ROM; ASCII-Format	U9 312/89/26
	A2.1.3	Mar 88	Emergency feed water supply into an isolated SG (no temperature equalization with the primary side)	CD-ROM; ASCII-Format	U9 312/88/54
	A2.2	Nov 88	Cooldown procedure with 3 SGs under loss of off-site power conditions	CD-ROM; ASCII-Format	U8 213/89/2018
	A2.2.1	Nov 88	Natural circulation behaviour under hot stand-by conditions (1 SG isolated)	CD-ROM; ASCII-Format	U9 312/89/23
	A2.2.2	Nov 88	Optimization of depressurization of the isolated SG under natural circulation conditions	CD-ROM; ASCII-Format	U9 312/89/12
A3: Criteria for Restarting RCPs					
	A3.2	May 88	Restart of RCPs in presence of a large steam bubble in the upper head	CD-ROM; ASCII-Format	U9 312/88/53
A4: Small Break on the Primary Side					
	A4.1	Dec 88	SB-LOCA, 40 cm 2 , cold leg	CD-ROM; ASCII-Format	U9 312/89/22
	A4.2	Dec 88	SB-LOCA, 40 cm 2 , cold leg, 2 isolated SGs	CD-ROM; ASCII-Format	U9 312/89/24
	A4.3	Dec 88	SGTR (1 tube), cooldown with 2 RCPs	CD-ROM; ASCII-Format	U8 21/89/2022
	A4.4	Dec 88	SGTR (1 tube), cooldown under NC conditions	CD-ROM; ASCII-Format	U8 21/89/2035
A5: Loss of Feedwater Transients					
	A5.2	Aug 88	Loss of feed water supply	CD-ROM; ASCII-Format	U9 312/89/25
	A5.2.1	Aug 88	Secondary side depressurization after loss of feed water supply	CD-ROM; ASCII-Format	U9 312/89/29

Table 5 - **PKL III B Test matrix (part 1)**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Siemens
B1: Investigation of Accident Management Procedures					
	B1.1	Nov 90	Loss of feed water with secondary-side bleed, core outlet > (Tsat + 50 K), feed from feed water line and discharged feed water tank	CD-ROM; ASCII-Format	E 312/92/17
	B1.2	Dec 90	Loss of feed water with secondary-side bleed, core outlet > (Tsat + 50 K), feed from feed water line and mobile pump	CD-ROM; ASCII-Format	E 312/92/18
	B1.3	Dec 90	Loss of feed water with primary-side bleed, RPV collapsed level below main coolant line, 4 high-pressure SIPs	CD-ROM; ASCII-Format	E 312/91/26
	B1.4	Dec 90	Loss of feed water with primary-side bleed, core outlet > (Tsat + 50 K), 4 high-pressure SIPs	CD-ROM; ASCII-Format	E 312/92/16
	B1.5	Jan 91	Station Blackout with primary-side bleed RPV collapsed level at main coolant line, 4 ACCs	CD-ROM; ASCII-Format	E 312/92/20
	B1.6	Jan 91	Station Blackout with primary-side bleed, core outlet > (Tsat + 50 K), 4 ACCs	CD-ROM; ASCII-Format	E 312/91/25
B2: Shutdown Procedures under Beyond-Design Conditions **(Multiple Failure Accidents)**					
	B2.1	Dec 89	Cooldown under loss of off-site power mode, 3 isolated SGs (CVCS available)	CD-ROM; ASCII-Format	R 232/90/2052
	B2.2	Jan 90	Cooldown under loss of off-site power mode, 3 isolated SGs, CVCS not available, RCPs available	CD-ROM; ASCII-Format	E 312/90/25
	B2.3	Feb 91	Small break in CL (24 cm 2), 100 K/h cooldown, 2 isolated SGs, 2 high-pressure SIPs, no operator actions	CD-ROM; ASCII-Format	E 312/92/15
	B2.4	Mar 91	Small break in CL (24 cm 2), 100 K/h cooldwon, 3 isolated SGs, 2 high-pressure SIPs, no operator actions	CD-ROM; ASCII-Format	S 552/92/25
	B2.6	Mar 91	Small break in CL (100 cm 2), 100 K/h cooldown, 2 isolated SGs, 1 high-pressure SIP (in broken leg), no operator actions	CD-ROM; ASCII-Format	E 312/92/19
	B2.8	Apr 91	SGTR in 10 U-tubes, cooldown with 2 RCPs and 1 SG due to the failure of 3 steam-line valves	CD-ROM; ASCII-Format	E 312/91/21

Table 6 - **PKL III B Test matrix (part 2)**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Siemens
B3: Detailed Investigation of Thermohydraulic Two-Phase Flow Phenomena					
	B3.1	Jun 89	Cooldown during natural circulation, 1 isolated SG (circulation in the loop with isolated SG is preserved by the cooldown rate)	CD-ROM; ASCII-Format	E 432/90/2087
	B3.2A	Jul 89	Natural circulation with various water inventory levels and KWU-PWR-type loop pressure drops	CD-ROM; ASCII-Format	E 312/90/10
	B3.2B	Dec 89	Natural circulation with various water inventory levels and Westinghouse-PWR-type loop pressure drops (counterpart test for LSTF ST-NC-08)	CD-ROM; ASCII-Format	E 312/90/19
	B3.3	Jul 90	Reflux-condensation mode, step-wise increase in the decay-heat rate from 1.5% to 5%, 4 SGs in operation	CD-ROM; ASCII-Format	E 312/91/15
	B3.4	Jul 90	Reflux-condensation mode, step-wise increase in the decay-heat rate from 1% to 5%, 1 SG in operation	CD-ROM; ASCII-Format	E 312/91/16
	B3.5.1	Jul 90	100 K/h cooldown under reflux-condensation mode, 4 SGs in operation, decay-heat rate approx. 2%	CD-ROM; ASCII-Format	E 312/91/24
	B3.6.1	Jul 90	Secondary-side bleed and subsequent feed with cold water, 4 SGs in operation, 2% decay-heat rate, reflux-condensation mode	CD-ROM; ASCII-Format	E 312/92/13
B4: Investigation of System Behaviour in Presence of Non-Condensible Gas in the Primary System					
	B4.1	Nov 89	Influence of the presence of nitrogen on natural circulation in the primary	CD-ROM; ASCII-Format	E 312/90/26
	B4.1.1	Nov 89	Influence of large amounts of nitrogen (equivalent to 8 ACCUs) on plant behavior	CD-ROM; ASCII-Format	E 312/91/18
	B4.2	Nov 89	Influence of the presence of nitrogen on two-phase natural circulation	CD-ROM; ASCII-Format	E 312/90/29
	B4.3	Dec 89	Influence of the presence of nitrogen on reflux-condensation mode	CD-ROM; ASCII-Format	E 312/90/28
	B4.5	Jul 90	RHRS failure during mid-loop operation	CD-ROM; ASCII-Format	E 312/91/13
B5: Steam Line Break					
	B5.1	Oct 89	Steam Line Break (10%)	CD-ROM; ASCII-Format	R 232/90/2011a

Table 7 - **PKL III C Test matrix (part 1)**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Siemens
C1: Primary Side Bleed and Feed (B+F) Following Small-Break LOCAs					
	C1.1	Jul 93	Primary side B+F, 10 cm 2 break, core outlet > (TSat + 50K), feed only with ACCs	CD-ROM; ASCII-Format	NT31/95/23+24
	C1.2	Jul 93	Primary side B+F, 40 cm 2 break, core outlet > (TSat + 50K), feed only with ACCs	CD-ROM; ASCII-Format	NT31/95/25+26
C2: Secondary or Primary Side B+F Following SGTR					
	C2.1	Dec 93	SGTR (1 tube), failure of SG relief valve, secondary side B+F in the intact SGs	CD-ROM; ASCII-Format	NT31/95/40+41
	C2.2	Nov 93	SGTR (1 tube), failure of SG relief valve, 50 K/h cooldown of the intact SGs, primary side bleed	CD-ROM; ASCII-Format	NT31/95/35+36
C3: Detailed Investigation of Reflux Condensation Phenomena					
	C3.1	Mar 93	Reflux-condenser mode, 4 loops and 1 loop in operation, SG loading 2-20%, primary pressure 18 bar	CD-ROM; ASCII-Format	NT31/94/87+88
	C3.2	Mar 93	Reflux-condenser mode, 4 loops and 1 loop in operation, SG loading 1-20%, primary pressure 8 bar	CD-ROM; ASCII-Format	NT31/95/01+02
C4: Secondary Side B+F Following Loss of Feedwater **(Non-Symmetric Boundary Conditions)**					
	C4.1	Jan 93	Secondary side B+F, loss of feedwater, core outlet > (TSat + 50 K), 2 SGs, mobile pump	CD-ROM; ASCII-Format	NT31/94/95+92
	C4.2	Dec 92	Secondary side B+F, loss of feedwater, core outlet = TSat , 4 SGs, feedwater tank	CD-ROM; ASCII-Format	NT31/95/49+50
	C4.3	Dec 92	Secondary side B+F, loss of feedwater, core outlet = TSat , 4 SGs, mobile pump	CD-ROM; ASCII-Format	NT31/95/15+16
C5: Primary Side B+F Following Loss of Feedwater or Station Blackout (Supplementary Tests)					
	C5.1.1	Apr 93	Primary side B+F, loss of feedwater, core outlet > (TSat + 50 K), 60 cm 2 , 1 SIP (pressurizer loops)	CD-ROM; ASCII-Format	NT31/95/12+13
	C5.2	Apr 93	Primary side B+F, Station Blackout, core outlet > (TSat + 50 K), 100 cm 2 , 4 ACCs, subsequent secondary side B+F	CD-ROM; ASCII-Format	NT31/94/70+74
	C5.3	May 93	Primary side B+F, loss of feedwater, core outlet > (TSat + 50 K), 100 cm 2 , 1 SIP (not pressurizer loop), RCPs in operation	CD-ROM; ASCII-Format	NT31/95/54+55

Table 8 - **PKL III C Test matrix (part 2)**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Siemens
C6: Small-Break LOCA under Multiple Failure Conditions					
	C6.1	Jun 93	SB-LOCA, 24 cm 2 , 100 K/h cooldown, 2 SGs isolated, N2 -injection into intact SGs	CD-ROM; ASCII-Format	NT31/94/47+48
	C6.2	Oct 93	SGTR (10 tubes), RCPs not in operation, cooldown of intact SGs, depressurization of defective SG via blowdown system	CD-ROM; ASCII-Format	NT31/94/72+73
	C6.3	Oct 93	SGTR (1 tube), RCPs not in operation, cooldown of intact SGs, depressurization of defective SG via blowdown system	CD-ROM; ASCII-Format	NT31/94/58+59
C7: Cooldown under Non-Symmetric Conditions (isolated SGs)					
	C7.1	May 92	50 K/h cooldown under loss of off-site power, 3 SGs isolated, after voiding of the isolated SG (primary side) cooldown of the isolated SG	CD-ROM; ASCII-Format	NT31/94/55+56
	C7.2	May 92	5-10 K/h cooldown under loss of off-site power, 1 SG isolated	CD-ROM; ASCII-Format	NT31/93/04+05
	C7.3	Apr 92	5-10 K/h cooldown under loss of off-site power, 3 SGs isolated	CD-ROM; ASCII-Format	NT31/94/25+26

Table 9 - PKL III D Test matrix

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Siemens
D1: Tests on Secondary Side Bleed-and-Feed (B+F)					
	D1.1	Nov 95	Early secondary side B+F under station blackout conditions, 1 MSRCV, passive injection from feedwater line system and feedwater tank	CD-ROM; ASCII-Format	NT31/97/30+31
	D1.2	Nov 95	Secondary side depressurization under SB-LOCA conditions with multiple system failures	CD-ROM; ASCII-Format	NT31/97/87+88
D2: Restart of Natural Circulation under SB-LOCA Conditions after Refill of the Primary System starting from Reflux Condenser Mode of Operation					
	D2.1	May 96	Cold leg break, cold leg injection (2 HP-SIPs)	CD-ROM; ASCII-Format	NT31/97/56+57
	D2.2	Oct 98	Hot leg break, symmetrical injection (hot and cold legs)	CD-ROM; ASCII-Format	NT31/99/80+81
D3: AM- Procedures followig SB-LOCA with Failure of the Safety Injection Systems					
	D3.1	Feb 96	Cooldown of 2 SGs via 1 MSRCV, primary side feed by 4 hot leg ACCs and with the CVCS	CD-ROM; ASCII-Format	NT31/97/74+75
D4: AM- Procedure following Loss of RHRS during mid-loop Operation and simultaneous Loss of Coolant					
	D4.1	Nov 97	Open man hole at the SG-inlet, stepwise primary-side feed by ACCs, afterwards by CVCS and extra-borating system	CD-ROM; ASCII-Format	NT31/98/7+8
D5: Optimization of Cooldown Procedures following SGTR (1 tube) under Emergency Power Conditions					
	D5.1	Jul 96	Early isolation of the defective SG and simultaneous cooldown of the intact SGs	CD-ROM; ASCII-Format	NT31/97/78+79
	D5.2	Jul 96	Delayed isolation of the defective SG after cooldown of all 4 SGs by a specified amount	CD-ROM; ASCII-Format	NT31/98/55+56
D6: Primary Side Bleed-and-Feed following Station Blackout Conditions					
	D6.1	Apr 97	Late primary side bleed (core outlet temperature > Tsat +50K) and feed by 8 ACCs	CD-ROM; ASCII-Format	NT31/99/61+62
D7: CCFL- Phenomena during Reflux Condenser Mode of Operation					
	D7.1	May 98	Secondary side feed by 1,2,3 or 4 emergency feedwater pumps into emptied SGs	CD-ROM; ASCII-Format	NT31/99/01+02
	D7.2	Jun 98	Secondary side feed by 4 emergency feed water pumps at secondary side water level: 5m	CD-ROM; ASCII-Format	NT31/99/87+88
D8: System Behaviour in Presence of Hydrogen in the Primary System					
	D8.1	Apr 99	Injection of helium (instead of hydrogen) above the upper end of the core	CD-ROM; ASCII-Format	NT31/99/76+77

Table 10 - *BETHSY Test Matrix: Accident management tests involving event oriented EOP's (Part 1)*

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. CEA
Small intermediate break					
1	4.2a	12/87	2" CL break not compensated by HPSI	ASCII format on an electronic medium	SETh/LES/87-22 SETh/LES/88-40
2	4.2a bis	1/88	2" CL break not compensated by HPSI	ASCII format on an electronic medium	SETh/LES/87-22 SETh/LES/88-41 SETh/LES/89-64
3	6.1a	1/91	3" CL break (SI on intact loops)	ASCII format on an electronic medium	SETh/LES/90-121 SETh/LES/91-17 SETh/LES/91-41
4	6.1b	2-3/91	3" CL break (SI on every loop)	ASCII format on an electronic medium	SETh/LES/90-121 SETh/LES/91-19 SETh/LES/91-54
5	8.1b	10/91	3" CL break, pumps on	ASCII format on an electronic medium	STR/LES/91-36 STR/LES/91-44 STR/LES/93-135
6	8.1c	11/91	3" CL break, delayed pump trip	ASCII format on an electronic medium	STR/LES/91-36 STR/LES/91-44 STR/LES/93-135
7	6.2TC	7/89	Bethsy - lstf counterpart test : 5 % CL side break	ASCII format on an electronic medium	SETh/LES/89-72 SETh/LES/89-77 SETh/LES/90-112
8	6.2	9/89	6" CL break	ASCII format on an electronic medium	SETh/LES/89-70 SETh/LES/89-80 SETh/LES/90-111
9	6.3	3/90	10" CL break	ASCII format on an electronic medium	SETh/LES/89-83 SETh/LES/90-98 SETh/LES/91-27
10	A-6.1c	11/96	EPR test - 3" CL break with realistic initial SG levels	ASCII format on an electronic medium	STR/LETS/96-28 STR/LETS/96-32 SETEX/LETS/97-20
11	6.4	11/93	6" HL break	ASCII format on an electronic medium	STR/LES/93-150 STR/LES/93-153 STR/LES/94-170

Table 11 - *BETHSY Test Matrix: Accident management tests involving event oriented EOP's (Part 1) – cont.ed*

Test matrix No.	**Exp. I.D.**	**Date**	Type (Characteristics)	**Data base and format**	**Test data report No. CEA**
Small intermediate break					
12	7.3	04/94	3" HL break wo HPIS with N2	ASCII format on an electronic medium	STR/LES/94-173 STR/LES/94-181 STR/LES/94-191
13	7.3b	02/97	3" HL break wo HPIS with N_2	ASCII format on an electronic medium	STR/LETS/97-01 STR/LETS/97-02 STR/LETS/97-16
14	6.5	3/89	Steam break at pressurizer, 3 relief valves	ASCII format on an electronic medium	SETh/LES/89-58 SETh/LES/89-69 SETh/LES/90-108
15	4.2b	12/93	Break at PV lower plenum	ASCII format on an electronic medium	STR/LES/94-151 STR/LES/94-161 STR/LES/94-180
16	6.8	5/92	RHRS break	ASCII format on an electronic medium	STR/LES/92-76 STR/LES/92-85 STR/LES/92-108
Steam generator tube rupture					
17	3.4b	12/88	SGTR (1 tube), with HPSI and AFW	ASCII format on an electronic medium	SETh/LES/87-27 SETh/LES/89-59 SETh/LES/90-94
18	4.3b	4/89	Multiple (6 t) SGTR	ASCII format on an electronic medium	SETh/LES/87-34 SETh/LES/89-73 SETh/LES/90-101
19	A3.4	06/98	EPR SGTR (2 t) with conservative assumptions	ASCII format on an electronic medium	SETEX/LETS/98-39 SETEX/LETS/98-42 SETEX/LETS/99-69

Table 12 - *BETHSY Test Matrix: Accident management tests involving event oriented EOP's (Part 2)*

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. CEA
Total loss of feedwater					
20	5.2c	6/89	Total loss of feedwater, 2 HPSI files, 3 relief valves	ASCII format on an electronic medium	SETh/LES/89-60 SETh/LES/89-76 SETh/LES/90-116
21	5.2c2	10/89	Total loss of feedwater (new EOP)	ASCII format on an electronic medium	SETh/LES/89-84 SETh/LES/89-60 SETh/LES/90-102
22	A-5.2c	12/95	EPR test - Total loss of feed water (MPSI in CL, ACC in HL, LPSI in HL/CL)	ASCII format on an electronic medium	STR/LES/95-249 STR/LES/95-254 STR/LETS/96-04
23	A9.4	11/97	EPR loss of feed-water without scram	ASCII format on an electronic medium	SETEX/LETS/97-19 SETEX/LETS/97-26 SETEX/LETS/98-30
Station black out					
24	5.2d	10/92	Loss of electric power and AFW	ASCII format on an electronic medium	STR/LES/92-100 STR/LES/92-109 STR/LES/93-139

Table 13 - *BETHSY Test Matrix: Accident management test involving the physical principles of the state-oriented approach*

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. CEA
25	3.4a	5/88	Natural circulation unbalanced by SG	ASCII format on an electronic medium	SETh/LES/88-42 SETh/LES/88-46 SETh/LES/90-96
26	4.1a	6/88	Two phase NC (2 % NP)	ASCII format on an electronic medium	SETh/LES/87-37 SETh/LES/88-49 SETh/LES/89-86
27	4.1a TC	9/88	Bethsy–Lstf counterpart test: two-phase NC	ASCII format on an electronic medium	SETh/LES/88-45 SETh/LES/88-55 STR/LES/90-103
28	4.1b	4/91	Two phase natural circulation, low pressure	ASCII format on an electronic medium	STR/LES/91-14 STR/LES/91-20 STR/LES/92-87
29	5.1a	11/88	Variation of mass inventory at SCS (natural circulation)	ASCII format on an electronic medium	SETh/LES/88-47 SETh/LES/89-63 SETh/LES/89-79
30	5.1a	1/89	Variation of mass inventory at SCS (forced convection)	ASCII format on an electronic medium	SETh/LES/88-47 SETh/LES/89-63 SETh/LES/89-79
31	8.1a	1-2/90	Two-phase flow forced convection	ASCII format on an electronic medium	SETh/LES/90-92 SETh/LES/90-95 STR/LES/92-60
32	7.2	10/90	Two-phase flow NC w non condensable gas	ASCII format on an electronic medium	SETh/LES/90-113 SETh/LES/90-120
33	5.2a	11/90	Feed and bleed at PCS	ASCII format on an electronic medium	SETh/LES/90-115 SETh/LES/90-123 STR/LES/92-67
34	5.1b	12/90	Unbalanced two-phase flow NC	ASCII format on an electronic medium	SETh/LES/90-118 SETh/LES/90-122 SETh/LES/92-71
35	4.1b	4/91	Two phase natural circulation, low pressure	ASCII format on an electronic medium	STR/LES/91-14 STR/LES/91-20 STR/LES/92-87
36	7.2c	3/92	SG heat transfer with non condensable gas (nitrogen)	ASCII format on an electronic medium	STR/LES/92-74 STR/LES/92-99
37	6.10	02/94	Long term PCS cooling after a LOCA	ASCII format on an electronic medium	STR/LES/94-166 STR/LES/94-169 STR/LES/94-188
38	10.2	06/96	SG heat transfer with non condensable light gas (helium)	ASCII format on an electronic medium	STR/LETS/96-10 STR/LETS/96-17 STR/LETS/97-40

Table 14 - BETHSY Test Matrix: Accident management test involving the physical pertinency of actions required in the state-oriented EOP's

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. CEA
39	9.1b	12/89	2" CL break w/o HPSI, delayed Ultimate Procedure	ASCII format on an electronic medium	STR/LES/89-88 STR/LES/90-91 STR/LES/90-105
40	8.1b	10/91	3" CL break, pumps on	ASCII format on an electronic medium	STR/LES/91-36 STR/LES/91-34 STR/LES/93-135
41	8.1c	11/91	3" CL break, delayed pump trip	ASCII format on an electronic medium	STR/LES/91-36 STR/LES/91-34 STR/LES/93-135
42	9.3	6/92	SGTR (1 tube) w/o HPIS and AFW	ASCII format on an electronic medium	STR/LES/92-70 STR/LES/92-86 STR/LES/93-134
43	5.2d	10/92	Loss of electric power and AFWS	ASCII format on an electronic medium	STR/LES/92-100 STR/LES/92-109 STR/LES/93-139
44	5.2e	09/93	Total loss of feedwater with delayed recovery of AFWS	ASCII format on an electronic medium	STR/LES/93-146 STR/LES/93-155 STR/LES/94-179
45	9.1a	12/94	2" CL break, fast depressurization of PCS	ASCII format on an electronic medium	STR/LES/94-205 STR/LES/95-213 STR/LES/95-234
46	6.6	10/95	3" CL break + 1 tube SGTR	ASCII format on an electronic medium	STR/LES/95-239 STR/LES/95-245 SETEX/LES/00-97

Table 15 - BETHSY Test Matrix: Characterization tests of the facility , counterpart test with nuclear plant

Test matrix No.	**Exp. I.D.**	**Date**	Type (Characteristics)	**Data base and format**	**Test data report No. CEA**
47	1.2 cont	87	Heat losses with trace heating	ASCII format on an electronic medium	SETh/LES/86-9 SETh/LES/89-66
48	3.1	87	Single phase natural circulation	ASCII format on an electronic medium	SETh/LES/86-17 SETh/LES/87-36 SETh/LES/89-62
49	1.3c	87	Characterization of downcomer mixer (low flow rates)	ASCII format on an electronic medium	SETh/LES/86-11
50	2.3	10/88	**BUBBLE FORMATION IN THE UPPER HEAD**	ASCII format on an electronic medium	SETh/LES/87-25 SETh/LES/88-56 SETh/LES/89-85
51	2.4/2.5	10/88	Normal spray efficiency	ASCII format on an electronic medium	SETh/LES/86-20 SETh/LES/87-31 SETh/LES/89-61 SETh/LES/89-82

Table 16 - BETHSY Test Matrix: Loss of heat removal system

Test matrix No.	**Exp. I.D.**	**Date**	Type (Characteristics)	**Data base and format**	**Test data report No. CEA**
52	6.9a	12/91	Loss of RHRS, pressurizer open	ASCII format on an electronic medium	STR/LES/91-51 STR/LES/92-103 STR/LES/92-111
53	6.9b	3/92	Loss of RHRS, pressurizer and SG inlet plenum open	ASCII format on an electronic medium	STR/LES/92-62 STR/LES/92-81 STR/LES/92-97
54	6.9c	4/92	Loss of RHRS, pressurizer and SG outlet plenum open	ASCII format on an electronic medium	STR/LES/92-62 STR/LES/92-82 STR/LES/92-110
55	6.9d	9/92	Loss of RHRS, PCS half open	ASCII format on an electronic medium	STR/LES/92-95 STR/LES/92-101 STR/LES/93-140
56	6.9e	06/95	Loss of RHRS, PCS half open with automatic forced feed in CL	ASCII format on an electronic medium	STR/LES/95-227 STR/LES/95-236 STR/LES/95-248
57	6.9f	02/96	Loss of RHRS, PCS half open + 2" CL break with automatic forced feed in CL	ASCII format on an electronic medium	STR/LETS/96-01 STR/LETS/96-03 STR/LETS/96-18
58	6.9g	03/98	Station blackout during mid-loop operation : loss of RHRS, PRZ man-way open, gravity driven water make up, effect of containment pressurisation	ASCII format on an electronic medium	SETEX/LETS/98-29 SETEX/LETS/98-33 SETEX/LETS/99-66

Table 17 - **BETHSY Test Matrix: Large break tests**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. CEA
59	6.7a1 to a4	5-6/90	Large break LOCA w/o non condensable gas	ASCII format on an electronic medium	SETh/LES/90-99 SETh/LES/90-109 STR/LES/91-10 STR/LES/91-11 SETh/LES/90-119
60	6.7b	7/90	Large break LOCA w non condensable gas	ASCII format on an electronic medium	SETh/LES/90-110 STR/LES/91-9
61	6.7c to h	02-05/93	Large break LOCA CL injection	ASCII format on an electronic medium	STR/LES/93-132 STR/LES/94-171 STR/LES/94-192 STR/LES/94-196 STR/LES/94-175 STR/LES/94-198 STR/LES/94-203
62	A6.7a to i	06-07/93	Large break LOCA CL/HL injection	ASCII format on an electronic medium	STR/LES/93-130 STR/LES/93-142
63	A6.7j1, j2, k2, l2	04-07/97	Large break LOCA (sensitivity studies on the reflooding phase with realistic condition)	ASCII format on an electronic medium	SETEX/LETS/97-05 SETEX/LETS/97-12 SETEX/LETS/98-35 SETEX/LETS/98-36 SETEX/LETS/98-37 SETEX/LETS/98-38
64	6.7m1, m2, m3	11-12/98	Large break LOCA (cold leg injection, sensitivity study of the effect of accumulator nitrogen injection and additional friction factor in CL)	ASCII format on an electronic medium	SETEX/LETS/98-53 SETEX/LETS/99-63 SETEX/LETS/99-80 SETEX/LETS/99-74 SETEX/LETS/99-78

Table 18 - **SPES Test Matrix**

Test matrix No.	Exp. I.D.	2.3.10.1.1 Dat e	Type (Characteristics)	Data base and format	Test data report No. SIET
1	SPFW02	Dec. 20, 1988	LOFW Loss of main feed-water with EFW delayed (ISP 22)	Binary proprietary available data on TK50 cartridge	NT/82
2	SPNC01	Apr. 13, 1989	SPNC Single-phase natural circulation (1-5% of nom. power)	2.3.10.1.2 Paper	0001RD89
3	SPNC04	Apr. 19, 1989	TPNC Two-phase natural circulation (5% of nominal power)	Paper	0002RD89
4	SPNC05	Apr. 26, 1989	TPNC Two-phase natural circulation (5% of nominal power) With secondary system degradation	Paper	0003RD89
5	SPNC03	May 3, 1989	TPNC Two-phase natural circulation (3% of nominal power)	Paper	0004RD89
6	SPNC02	May 5, 1989	TPNC Two-phase natural circulation (1% of nominal power)	Paper	0005RD89
7	SPST01	Nov. 15, 1989	SBO Station black-out with PORV bleed	Binary proprietary available data on TK50 cartridge	0006RD89
8	SPFW03	Apr. 4, 1991	LOFW Loss of feed-water with bleed and feed	Binary proprietary available data on TK50 cartridge	0066RD91
9	SPSB03	June 14, 1991	SBLOCA 6" SBLOCA SPES-LOBI-BETHSY-LSTF counterpart test at decay power	Binary proprietary available data on TK50 cartridge	0091RD91
10	SPSB04	Nov. 23, 1991	SBLOCA6" SBLOCA SPES-LOBI-BETHSY-LSTF counterpart test at full power	Binary proprietary available data on TK50 cartridge	0136RD92

Table 19 - **SPES-2 Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Westinghouse
1	S00103	Feb 5, 1994	SBLOCA 2 inch CL break, CVCS, NRHR,SFW off, PRHR On, ADS 4th stage B failure. Sharp orifice at the break.	DDS 60m 4mm Cartridge	WCAP-14039 Rev.1
2	S00203	April 9, 1994	SBLOCA 2 inch CL break, CVCS, NRHR,SFW off, PRHR On, 1 of 2 ADS 4th stage B valves failure. Smooth orifice at the break.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
3	S00303	April 30, 1994	SBLOCA 2 inch CL break, CVCS, NRHR,SFW off, PRHR On, 1 of 2 ADS 4th stage B valves failure. As above without PR balance line. Reference CL break.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
4	S00401	May 6, 1994	SBLOCA 1 inch CL break, CVCS, NRHR,SFW off. PRHR On, 1 of 2 ADS 4th stage B valves. Maximize CMT heatup prior to ADS actuation.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
5	S00504	May 18, 1994	SBLOCA 2 inch CL break, CVCS, NRHR,SFW on, PRHR On. No 4th stage actuation Non safety/passive system interaction.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
6	S00605	May 27, 1994	SBLOCA 2 inch DVI break, CVCS, NRHR,SFW off., PRHR On, 1 of 2 ADS 4th stage B valves failure. Asymmetric CMT performance.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
7	S00706	June 10, 1994	SBLOCA DEG break of DVI, CVCS, NRHR,SFW off.. PRHR On. 1 of two ADS 1st and 3rd stage valves failure. Complete loss of one-of-two PXS subsystems.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
8	S00908	June 23, 1994	SBLOCA CMT BL DEG break , CVCS, NRHR,SFW off., PRHR On. 1 of 2 ADS 1st and 3rd stage valves failure. No delivery from faulted CMT. **Blind test.**	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
9	S01007	July 7, 1994	SBLOCA 2 inch CMT BL break, CVCS, NRHR,SFW off, PRHR On. 1 of 2 ADS 4th stage B valves failure. Examine effect on CMT draindown.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
10	S01110	July 14, 1994	SGTR SG tube rupture (1 tube), CVCS, NRHR,SFW off., PRHR On. No failure. No operator actions.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
11	S01211	Sept 7, 1994	SGTR SG tube rupture (1 tube), CVCS, NRHR,SFW off, PRHR On. 1 of 2 ADS 4th stage B valves failure. Inadvertent ADS opening. **Blind test.**	DDS 60m 4mm cartridge	WCAP-14039 Rev.1
12	S01309	Sept 22, 1994	SGTR SG tube rupture (1 tube), NRHR off. SFW, CVCS on, PRHR On. No failure. Operator action to isolate SG, subcool and depressurize primary system.	DDS 60m 4mm cartridge	WCAP-14039 Rev.1

Table 20 - **SPES-2 Test Matrix – cont.ed**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. Westinghouse
13	S01512	Oct 11, 1994	SLB SG A steam line break , CVCS, NRHR,SFW off, PRHR On (3 tubes). FW not isolated on T cold signal. Maximum PRHR cooldown. CMT's do not drain and no ADS actuation occurs. **Blind test.**	**DDS 60m 4mm** cartridge	WCAP-14039 Rev.1
14	S01613	Oct 15, 1994	SBLOCA 1 inch CL break, CVCS, NRHR,SFW off. PRHR On (3 tubes). 1 of 2 ADS 4 th stage B valves failure. Show effect of 2 PRHR HX's on cold leg temperature.	**DDS 60m 4mm** cartridge	WCAP-14039 Rev.1
15	S01703	Nov. 12, 1994	SBLOCA 2 inch CL break, CVCS, NRHR,SFW off. PRHR On. 1 of 2 ADS 4th stage B valves failure. Reference CL break repeatability test.	**DDS 60m 4mm** cartridge	WCAP-14039 Rev.1

Table 21 - **SPES-99 Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. SIET
1	SPIB10	July 29, 1999	IBLOCA Intermediate break 6” at full power. AP600 configuration with only accumulators available as safety systems	Data available as Microsoft Excel file	00777 RP 99

Table 22 - **LOBI Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
1	A1-04	12.12.79	200% CL break LOCA , AIS in CL, DC 50 mm first test in power ascension series, 1.8 FPS, PREX test	DNB, early rewet, dryout, final rewet, system performance at low power, 18	JRC-STRESA	EDR EUR6970 QLR EUR6969
2	A1-01	29.01.80	200% CL break LOCA, AIS in CL+HL, DC 50 mm second test in power ascension series, 3.0 FPS	DNB, early rewer, dryout, final rewet, oscillatory refill behaviour, DEGB partially communicative	JRC-STRESA	EDR 3807 QLR 3806
3	A1-02	14.02.80	200 % CL break LOCA, AIS in CL+HL, DC 50 mm third test in power ascension test series, 8.2 FPS	DNB, early rewet, dryout, final rewet, oscillatory refill behaviour	JRC-STRESA	EDR 3810 QLR3809
4	A1-03	19.03.80	200% CL break LOCA, AIS in CL+HL, DC 50 mm fourth test in power ascension series 8.8 FPS, power off from 3.2s to 5s	DNB, early rewet, dryout, final rewet, oscillatory refill behaviour	JRC-STRESA	EDR 3801 QLR 3800
5	A1-04R	17.04.80	200% CL break LOCA, AIS in CL, DC 50 mm counterpart to A1-04 at nominal power 10.2 FPS, baseline CL LOCA	DNB, early rewet, dryout no final rewet before power shutoff, no sustained oscillation during refill	JRC-STRESA	EDR 3803 QLR 3802
6	A1-05	06.05.80	200% CL break LOCA, AIS in CL+HL, DC 50 mm counterpart to A1-04R with respect to AIS mode, enhanced AIS injection, 10.2 FPS	DNB, early rewet, dryout no effective improvement of AIS performance, oscillatory refill behaviour	JRC-STRESA	EDR 3812 QLR 3811
7	SD-SL-01	04.06.80	10% CL break LOCA, ECCS in CL first small break LOCA scoping test instrumentation response to slow transients link between small and large break LOCAs	No degradation of core heat transfer	JRC-STRESA	EDR 3951 QLR 3966
8	SD-SL-02	04.06.80	1% CL break LOCA, ECCS in CL, DC 50 mm second small break LOCA scoping test secondary 100 K/h cooldown	Flow to the break mainly from vessel side, flow from pump side impeded due to closure of break valve, no degradation of core heat transfer	JRC-STRESA	EDR 3956
9	SD-SL-03	24.09.80	0.4% CL break LOCA, ECCS in CL, DC 50 mm third test of the small break LOCA scoping series secondary 100 K/h cooldown, HPIS represented by MCP seal water injection	No degradation of core heat transfer, natural circulation and reflux condenser heat transport detected	JRC-STRESA	EDR 3805 QLR 3804

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
10	A2-59	27.10.80	100% CL break LOCA, AIS in CL, DC 50 mm first test of interim matrix, system response to communicative break	DNB, early rewet, dryout, final rewet, clear bottom-up rewet trend, response similar to DEGB	JRC-STRESA	EDR 3950 QLR 3960
11	B-101	26.11.80	2x50% CL break LOCA, AIS in CL, DC 50 mm second test of the interim matrix, Influence of non-communicative break configuration	DNB, early rewet comparison of B-101 with A2-59 precluded by difference in power load	JRC-STRESA	EDR 3940 QLR 3939
12	A2-55	19.01.81	50% CL break LOCA, AIS in CL, DC 50 mm third test of the interim matrix, system response to intermediate large break sizes	DNB and early rewet only at core upper levels, thereafter effective core cooling prevailed	JRC-STRESA	EDR 3941 QLR 3945
13	A2-59R	11.02.81	100% CL break LOCA, AIS in CL, DC 50 mm fourth test of interim matrix, Counterpart to A2-59 with respect to reproducibility	A2-59R and A2-59 system thermal-hydraulic response similar, MOD1reproducibility confirmed	JRC-STRESA	EDR 3957 QLR 3960
14	B-R1M	17.03.81	25% CL break LOCA, AIS in CL, DC 50 mm fifth test of the interim matrix system response to small large break sizes	core thermal response followed prevailing system saturation temperature, no core thermal excursions tendency to loop seal formation	JRC-STRESA	EDR 3816 QLR 3815
15	A1-66	03.07.81	200% CL break LOCA, AIS in CL baseline test, DC 12 mm counterpart to A1-04R with respect to DC size	DNB, early rewet at core bottom and top ends, dryout, no conclusive rewet observed, CCFL and hot wall delay effects in downcomer	JRC-STRESA	EDR 3818 QLR 3817
16	A1-07	09.07.81	200% CL break LOCA, AIS disabled, DC 12 mm system response with no ECCS baseline test for ECCS injection mode	DNB, early rewet at core bottom and top ends dryout, rod temperatures high after power shutoff	JRC-STRESA	EDR 3943 QLR 3947
17	A1-06	21.07.81	200% CL break LOCA, AIS in CL+HL, DC 12 mm system response with combined ECCS injection baseline test with respect to ECC injection mode	DNB, early rewet at core bottom and top ends, dryout, heater rod temperature turnaround after ECC injection starts, no clear rewet with power on	JRC-STRESA	EDR 3952 QLR 3955
18	A1-67	30.09.81	25% CL break LOCA, AIS in CL+HL, DC 12 mm system response to a small large break LOCA break size test series	delayed dryout at core mid and upper elevations rewet, tendency towards small break LOCA features, loop seal formation and clearout	JRC-STRESA	EDR 3942 QLR 3938

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
19	A1-68	28.10.81	50% CL break LOCA, AIS in CL+HL, DC 12 mm system response to intermediate break sizes break size test series	dryout, rewet, clear top-down rewet behaviour	JRC-STRESA	EDR 3944 QLR 3953
20	A1-10A	25.11.81	200% HL break LOCA, AIS in HL+CL, DC 12 mm system response to hot leg break break location test series, core power low	dryout, rewet only at core mid and upper elevations, hot leg ECC core penetration hindered by sustained positive core flow, CCFL at core exit	JRC-STRESA	EDR 3958 QLR 3964
21	A1-10B	10.12.81	200% HL break LOCA, AIS in HL+CL, DC 12 mm system response to hot leg break, similar to A1-10A break location test series, nominal core power	dryout, rewet limited at core upper elevations, higher peak cladding temperatures with respect to A1-10A, CCFL at core exit	JRC-STRESA	EDR 3959 QLR 3963
22	A1-70	13.01.82	200% PS break LOCA, AIS in CL+HL, DC 12 mm system response to pump suction break break location test series	DNB, rewet, less severe overal core heat transfer degradation with respect to similar cold and hot leg break DEGB-LOCA	JRC-STRESA	EDR 3969 QLR 3965
23	A1-73	04.02.82	25% HL break LOCA, AIS in CL+HL, DC 12 mm system response to hot leg small large break LOCA break size and break location test series	no core heat transfer degradation, heater rod temperatures at the prevailing system saturation temperature	JRC-STRESA	EDR 3976 QLR 3970
24	A1-72	24.03.82	200% CL break LOCA, AIS in CL+HL, DC 12 mm influence of pump operation mode, pump coastdownd delayed off, pump head simulation	DNB, early rewet, dryout, enhancement of initial recovery of positive core flow, lower peak cladding temperatures with respect to A1-06	JRC-STRESA	EDR 3977 QLR 3971
25	A1-69	06.04.82	100% CL break LOCA, AIS in CL+HL, DC 12 mm, system response to intermediate large break LOCA, break size effect test series	DNB, early rewet, dryout, final rewet, typical DEGB LOCA blowdown features, preferentially top-down rewet observed	JRC-STRESA	EDR 3978 QLR 3972
26	A1-74	21.04.82	200% CL break LOCA, AIS in CL+HL, DC 12 mm, system response to ECCS injection in both intact and broken loop, counterpart to A1-72	DNB, early rewet, dryout, no discernible impact on overall system response from addition of ECC injection into broken loop	JRC-STRESA	EDR 3979 QLR 3973

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
27	B-222	05.05.82	100% CL break LOCA, AIS in CL, DC 12 mm non-communicative (2x50%) CL break configuration, counterpart to B-101 with respect to downcomer size	DNB, early rewet, dryout, limited effectiveness of cold leg ECCS injection	JRC-STRESA	EDR 3980 QLR 3974
28	B-302	16.0.82	100% HL break LOCA, AIS in CL, DC 12 mm non-communicative (2x50%) HL break configuration	dryout at core mid and upper elevations, rewet, positive core flow throughout the whole transient, enhanced refill and effective core cooling	JRC-STRESA	EDR 4008 QLR 3975
29	A1-76	12.04.84	SG Performance under primary forced circulation, variation of secondary inventory and core power: - flooding of SG coarse separator at nominal core power - flooding of SG coarse separator at 50% core power and reduced secondary water level - boiloff of SG secondary side at 10% core power	data on coarse and fine separator efficiency, variation of recirculation ratios, void distribution in the SG riser region, degradation of SG heat transfer	JRC-STRESA	EDR 4018 QLR 4021
30	A2-81	27.09.84	1% CL break LOCA, HPIS in CL, AIS off secondary cooldown at 100 K/h, DC 12 mm first test of the small break LOCA test series, OECD International Standard Problem 18 (ISP 18)	1 coupling of primary and secondary systems, 2 phase NC and reflux condenser heat transport, flow separation and stratification in horizontal pipes liquid hold-up in hot legs and SG U-tubes	JRC-STRESA	EDR 4019 QLR 4022
31	A1-82	28.09.84	1% CL break LOCA, HPS in HL, AIS in HL+CL secondary cooldown at 100K/h, DC 12 mm, counterpart to A2-81 relatively to HPIS location	coupling of primary and secondary systems, 2 phase NC and reflux condenser heat transport, low subcooling in pressure vessel downcomer, reduced ECC bypass to the break	JRC-STRESA	EDR 4020 QLR 4026
32	A1-78	24.10.84	2% CL break LOCA, HPIS in HL, AIS in HL+CL secondary cooldown at 100 K/h, DC 12 mm, test of the break size effect test series	decoupling of primary and secondary systems, reverse SG heat transfer, voiding in SG U-tubes and liquid hold-up in hot legs, loop seal formation and core liquid level depression	JRC-STRESA	EDR 4023 QLR 4027

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
33	A2-77A	28.11.84	characterization of NC and reflux condenser heat transport mechanisms at a primary system pressure of 90 bar and 70 bar, DC 12 mm, - 90 bar: 1 and 2 phase NC and reflux condenser - 70 bar 2 phase NC and reflux condenser	NC heat transport mechanisms characterized as function of primary system mass inventory, minimum mass inventory of c. 45% at c. 3% of core power to sustain effective reflux heat transport and prevent core heat transfer degradation, oscillatory transition from 2 phase NC to reflux	JRC-STRESA	EDR 4024 QLR 4044
34	A1-83	19.12.84	10% CL break LOCA, HPIS in HL, AIS in HL+CL secondary cooldown at 100 K/h, DC 12 mm larger of the break size effect test series	decoupling of primary and secondary systems, early voiding of SG U-tubes and hot legs, initial core dryout and rewet coupled to loop seal formation and clear-out, second core dryout and rewet coupled to mass inventory boiloff and AIS injection	JRC-STRESA	EDR 4025 QLR 4028
35	A2-90	27.03.85	LONOP-ATWS otherwise referred to as 'SBO', anticipated transient caused by loss of offsite and normal on-site electrical power with failure to SCRAM - boiloff of SG secondary system down to a level of c 1m above tube plate, - SG refill and cooldown at 100 K/h	pressure increase in primary and secondary systems, fluid discharge from pressurizer PORV and SG SRV pressurizer insurge/outsurge, SG heat transfer degradation, re-establishment of primary to secondary heat transfer, 1 and 2 phase NC	JRC-STRESA	EDR 4031 QLR 4034
36	A1-85	07.05.85	0.4% PZR break LOCA, HPIS in HL, AIS in HL+CL secondary cooldown at 100 K/h, DC 12 mm test of the break location effect test series	coupling of primary and secondary systems, pressurizer insurge, primary system overfeeding	JRC-STRESA	EDR 4032 QLR 4035
37	BL-00	03.07.85	0.4% CL break LOCA, HPIS in CL secondary cooldown at 57 K/h, DC 12 mm, first test of the EC B test matrix	primary and secondary systems thermally coupled, liquid hold-up in SG U-tubes, stratification in horizontal pipework, thermal non-equilibrium downstream ECC injection points, 2 phase and reflux condenser heat transport, primary overfeeding and refill, no core dryout	JRC-STRESA	EDR 4039 QLR 4045
38	A1-84	14.10.85	10% HL break LOCA, HPIS in HL, AIS in CL+HL secondary cooldown at 100 K/h, DC 12 mm test of the break location effect test series, counterpart to A!-83	decoupling of primary and secondary systems, early voiding of SG U-tubes and hot legs, hold-up and CCFL at core exit, ECC penetration and flow channeling	JRC-STRESA	EDR 4037 QLR 4042

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
39	BT-00	30.11.85	LOFW with primary Feed and Bleed . loss of main feedwater and SG boildown to c. 1m . loss of auxiliary fedwater and SG dryout . long term cooldown via primary Feed and Bleed	SG boil-off and heat transfer degradation, PORV and SRV fluid discharge, Pressurizer insurge/outsurge, PORV flow compensation via HPIS flow, Primary system refill, Verification of Feed and Bleed as an Accident Management procedure	JRC-STRESA	EDR 4038 QLR 4041
40	BT-01	24.01.86	10% SLB with PTS and plant recovery procedure . small steam line break transient . establishment of PTS conditions . accident mitigation and recovery procedures	SG secondary blowdown and heat transfer, primary system cooldown rate, pressurizer insurge/outsurge, downcomer temperature stratification, primary depressurization via PRZ cooling system and mass inventory control via HPIS injection	JRC-STRESA	EDR 4046 QLR 4337
41	BL-02	22.03.86	3% CL break LOCA, HPIS in CL, AIS in CL SCS cooldown at 56 K/h, DC 12 mm test of the break size effect test series	primary and secondary systems decoupled, SG heat transfer reversed, formation and clear-out of loop seal, no core dryout	JRC-STRESA	EDR 4047 QLR 4212
42	A1-79	15.05.86	1% CL break LOCA, HPIS in HL, AIS off secondary cooldown at 100 K/h, DC 12 mm effect of high (4/4) HPIS injection rate	coupling of primary and secondary systems primary system overfeeding, NC heat transport hindered by condensation in hot legs and upper plenum induced by high HPIS rate	JRC-STRESA	EDR 4206 QLR 4210
43	A1-88	11.06.86	0.4% CL break LOCA, HPIS in HL, AIS off SCS cooldown at 100 K/h in IL-SG, DC 12 mm asymmetric cooldown of secondary system	primary system pressure coupled to isolated SG, pressurizing effect of isolated SG, primary system repressurization, break flow compensated by HPIS flow	JRC-STRESA	EDR 4204 QLR 4211
44	BL-01	20.09.86	5% CL break LOCA, HPIS in HL, AIS on secondary cooldown at 100 K/h, DC 12 mm test of the break size effect test series	decoupling of primary and secondary systems, SG reverse heat transfer, clear-out of intact loop seal, liquid hold up in HL	JRC-STRESA	EDR 4207 QLR 4213
45	BC-01	18.10.86	SG secondary mass inventory determination LOBI-MOD2 characterization test	SG mass inventory determined at various power levels, relationship of SG mass vs. downcomer water level determined	JRC-STRESA	EDR 4221 QLR 4222

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
46	BC-02	26.11.86	SG heat losses determination LOBI-MOD2 characterization test	SG heat losses determined via: . steady-state method balancing core power . cooldown method SG heat losses unacceptably high: ILSG: 24 kW, BLSG: 18 kW, request for improvement of thermal insulation	JRC-STRESA	EDR 4231 QLR 4230
47	BL-21	24.01.87	SGTR: Steam Generator Tube Rupture (0.4%) Intentional PCS depressurization through PORV and AIS actuation as recovery procedure	Break and PCS depressurization, Natural circulation and reflux condenser heat transport, Core uncovery and dryout, PORV discharge, AIS actuation and core rewet	JRC-STRESA	EDR 4214 QLR 4225
48	BL-12	19.02.87	1% CL Break LOCA, HPIS off, AIS in CL SCS cooldown off, DC 12 mm System response with degraded safety systems	Core uncovery and dryout at high PCS pressure, Phase separation and stratification, thermal non-equilibrium downstream AIS location, loop seal formation and clearout, Core rewet	JRC-STRESA	EDR 4215 QLR 4209
49	BT-02	09.05.87	LOFW+LOAF: Loss of Main and Auxiliary Feedwater PCS Bleed and Feed as recovery procedure	SG boiloff and heat transfer degradation, PCS heatup and pressurization, pressurizer insurge/outsurge, PORV discharge and HPIS compensation, recovery of PCS inventory	JRC-STRESA	EDR 4216 QLR 4243
50	BT-12	17.06.87	SLB: Steam Line Break (100% orifice limited) SCS break size effect and location test series	Faulted SG depressurization, break flow and steam line carryover, faulted SG heat extraction, reverse heat transfer in unaffected SG, pressurizer behaviour, PCS overcooling and thermal stratification	JRC-STRESA	EDR 4217 QLR 4340
51	A1-91	26.09.87	1% CL break LOCA, HPIS in HL, AIS off secondary cooldown at 100 K/h, DC 12 mm effect of low (1/4) HPIS injection rate	PCS and SCS thermal coupling, core thermal response with reduced HPIS capacity, core liquid level depression, loop seal formation, no core dryout at reduced HPIS capacity	JRC-STRESA	EDR 4223 QLR 4220
52	BT-03	24.10.87	LOFW-ATWS: Loss of Feed Water - Anticipated Transient Without SCRAM PCS Passive Recovery Procedure	PCS heat-up and pressurization PORV and SRV discharge, voiding and refill of SG, pressurizer insurge/outsurge, intentional PCS depressurization and AIS actuation, core dryout	JRC-STRESA	EDR 4219 QLR 4241

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
53	A1-92	30.11.87	Characterization of NC and reflux condenser heat transport at a primary pressure of 40 bar, 1 and 2 phase NC and reflux condenser, counterpart to PKL test AC.1	NC and reflux condenser heat transport mechanisms as function of primary mass inventory, minimum mass inventory to sustain reflux condenser and prevent core heat transfer degradation c. 45%, rather stable transition from 2 phase NC to reflux condenser	JRC-STRESA	EDR 4224 QLR 4226
54	BL-16	19.03.88	0.4% Small Break LOCA, HPIS in HL, AIS off SCS cooldonwn in BLSG at 100 K/h, DC 12 mm MCPs off and restart	Asymmetric SCS cooldown, pressurizing effect of isolated SG, thermal homogenization and fluid redistribution following MCPs restart	JRC-STRESA	EDR 4228 QLR 4342
55	BC-03	15.04.88	SG Heat Losses determination LOBI-MOD2 characterization test	Measurement of SG heat losses after improvement of thermal insulation (ref.: BC-02) ILSG: 6.8 kW, BLSG: 5.0 kW	JRC-STRESA	EDR 4235 QLR 4236
56	A1-93	30.04.88	2% CL break LOCA, HPIS off, AIS on secondary system cooldown at 100 K/h, DC 12 mm accident management procedure, pressurizer PORV on on high core heater rod temperature	Decoupling of primary and secondary systems, loop seal formation and core level depression, core dryout and AIS injection, enhancement of primary depressurization and AIS actuation through intentional opening of pressurizer PORVs	JRC-STRESA	EDR 4233 QLR 4232
57	A1-94	27.05.88	4% CL break LOCA at 40 bar, HPIS off, AIS on LOBI counterpart to PKL test, secondary system cooldown, DC 12 mm AIS on at high core heater rod temperature	Core uncovery and dryout, AIS injection and core rewetting, verification of PKL-III pressure scaling concept,	JRC-STRESA	EDR 4234 QLR 4242
58	BC-04	07.02.89	Core bypass flow measurement LOBI-MOD2 characterization test	Determination of upper plenum to upper downcomer flow bypass: c. 3% of core flow	JRC-STRESA	QLR 4330
59	BL-30	15.04.89	5% CL Break LOCA, HPIS in CL, AIS in CL SCS cooldown at 100 K/h, DC 12 mm Test of the break size effect test series	Primary depressurization at a moderate rate, primary and secondary systems thermally decoupled, loop seal formation and clearout	JRC-STRESA	EDR 4329 QLR 4331
60	BL-22	17.06.89	SGTR: Steam Generator Tube Rupture (0.4%) Accident initiation and mitigation phases	Break flow, overfilling of affected SG and SRV discharge, auto-stabilizing mechanism for break flow when affected SG level reaches U bend elevation, verification of emergency operating procedures	JRC-STRESA	EDR 4328 QLR 4339

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
61	A1-87	11.11.89	Cooldown transient, LOBI counterpart to PKL-III test	1 phase NC under saturated conditions, upper head steam bubble formation and propagation, SG heat transfer	JRC-STRESA	EDR 4332 QLR 4334
62	BT-04	10.02.90	Cooldown Transient under asymmetric conditions BLSG isolated, ILSG cooldown at 56 K/h	Reverse heat transfer in isolated SG, pressurizing effect of isolated SG, flow reversal in secondary of isolated SG	JRC-STRESA	EDR 4351 QLR 4354
63	BL-34	22.03.90	6% CL Break LOCA, HPIS off, AIS on at 40 bar initial conditions scaled to low power (10%) SCS cooldown disabled, DC 12 mm Counter Part Test to BETHSY, LSTF and SPES	Sequence of 3 core thermal excursions 1) dryout and rewet due to loop seal formation and clearout, 2) dryout due to boiloff and rewet due to AIS, 3) dryout due to depletion of AIS injection and rewet due to LPIS injection.	JRC-STRESA	EDR 4335 QLR 4338
64	BL-44	26.04.90	6% CL Break LOCA, HPIS off, AIS on at 40 bar initial conditions scaled to full power (100%) SCS cooldown disabled, DC 12 mm Counter Part Test to BL-34 (full power - low power)	Phenomenologies similar to BL-34, sequence of 3 core dryout/rewet phases, first dryout less extensive due to less pronounced core liquid level depression	JRC-STRESA	EDR 4336 QLR 4343
65	BT-56	03.07.90	Multiple Failure Transient evolving from an original LOFW: isolation of ILSG, MCP power off, SCRAM failure, PCS blowdown through upper plenum due to rupture os the safety disk.	PCS heatup and pressurization, pressurizer insurge/outsurge, primary and secondary systems decoupled, dryout at high pressure, blowdown of the PCS through a relatively large break in upper plenum represented by the rupture disk opening	JRC-STRESA	EDR 4352 QLR 4356
66	BT-15/16	22.11.90	LOFW: Loss of Feed Water with MCP on (BT-15) SG boiloff and refill with MCPs off (BT-16)	BT-15: SG boiloff and heat transfer degradation with MCPs on, primary system heatup, reestablishment of SG heat transfer following AFW actuation, BT-16: SG boiloff and heat transfer degradation with MCPs off, natural circulation in PCS, SG refill	JRC-STRESA	EDR 4346 QLR 4347

(*) available in electronic format on the JRC-STRESA web-based informatic platform

LOBI Test Matrix - cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format(*)	Test data report No. JRC
67	BT-17	07.02.91	LOFW; Loss of Feed Water and Secondary Feed and Bleed recovery procedure Intentional PCS depressurization from Upper plenum	SG boiloff, PCS heatup and pressurization, presurizaer insurge and PORV discharge, SCS blowdown and PCS depressurization due to condensation in SG U-tubes, PCS depressurization from upper plenum, pressurizer outsurge, core dryout and partial rewet.	JRC-STRESA	EDR 4344 QLR 4341
68	BT-06	21.03.91	FLB: Feed Line Break (10%) MCPs on, AFW on in ILSG MCPs off and asymmetric natural circulation in PCS with a voided SG	Blowdown and heat transfer from faulted SG, break flow feed from different flow paths, residual heat removal by unaffected SG, pressurizer insurge/outsurge	JRC-STRESA	EDR 4348 QLR 4349
69	BL-40	16.05.91	SGTR: Steam Generator Tube rupture in 1-loop PWR (Jose' Cabrera NPP), E-3 emergency recovery procedures	Break flow, PCS natural circulation, PCS depressurization and control of subcooling margin and pressurizer level cycling PORV and HPIS flow.	JRC-STRESA	EDR 4345 QLR 4353
70	BL-06	21.06.91	1% CL Break LOCA, HPIS off, AIS on at 40 bar SCS cooldown as in BL-12, MCPs on Effect of MCP on/off issue	PCS depressurization with MCPs on, core dryout and rewet, PCS pressure stagnation, termination of AIS injection, depressurization from PORV and actuation of LPIS.	JRC-STRESA	EDR 4350 QLR 4355

(*) available in electronic format on the JRC-STRESA web-based informatic platform

Table 23 - **UPTF 2D/3D Test matrix (part 1)**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
1	020 021 023 025 026		**SET: High pressure injection test** Fluid-fluid mixing in downcomer; thermal loading of the reactor pressure vessel wall	- Test vessel pressure: 18 bar - Test vessel and loops initially filled with hot water: 190°C - ECC temperature: 32°C - All pump simulators and hot and cold leg break valves closed - ECC injection in cold leg 2: 5, 10, 20, 40, 70 kg/s	CD-ROM; binary unit	R 515/87/1
2	101		**IT: US/J-PWR integral test** Investigation of the two-phase flow behavior in hot and cold legs, downcomer, upper plenum and at the tie plate under steady state reflood conditions	**Double-ended (2A) cold leg break Evaluation model (EM) conditions** - Initial pressure: Test vessel: 2.5 bar Containment simulator: 2.5 bar - Initial lower plenum inventory: 49460 kg - ECC temperature: 42°C - Broken loop cold leg fully open - Broken loop hot leg open: K = 18.2 - All intact loop pump simulators partly open: K = 17.3 - ECC injection into intact cold legs 1, 2 and 3: 423/80 kg/s per leg - CS water injection: 98/25 kg/s - CS steam injection: 118-88 kg/s - SG simulation steam: 4.4-3.7 kg/s/SGS - N_2 injection	CD-ROM; binary unit	U9 316/88/2
3	C5		**IT: GPWR integral test** Investigation of the two-phase flow behavior in loops, upper plenum, tie plate region and downcomer; water breakthrough events at tie plate and in downcomer; water plug formation and movement in injecting hot and cold legs	**Double-ended (2A) cold leg break Evaluation model (EM) conditions Conditioning phase 18-10.5 bar** - Initial pressure: Test vessel: 18 bar Containment simulator: 4 bar - Initial lower plenum inventory: 8900 kg - ECC temperature: 30°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 18.2 - All intact loop pump simulators partly open: K = 12 - ECC injection in cold legs 1-3 and in hot legs 2, 3 and broken hot leg (HL4) - CS water injection - Core simulator steam injection controlled by feedback system - SG simulator steam: 15 kg/s - No simulation of SG behavior - N_2 injection - Pressurizer simulation: 83 kg/s steam injection	CD-ROM; binary unit	R 515/87/15

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
4				- Broken loop cold leg fully open - ECC temperature: 33°C - No N_2 injection	CD-ROM; binary unit	E 314/90/06
	174/A		**SET: Downcomer test** Investigation of the two-phase flow behavior in downcomer and lower plenum during end-of blowdown and refill phases	**Transient:** **Large cold leg break** - Initial pressure: Test vessel: 12 bar Containment simulator: 2.5 bar - Initial lower plenum inventory: 7900 kg/s - ECC temperature: 37°C - Broken loop hot leg open: K = 3.9 - All intact loop pump simulators partly open: K = 6.6 - ECC injection into intact cold legs 1, 2 and 3: 385/630 kg/s per leg - CS steam injection: 22 kg/s - SG simulator steam: 20 kg/s/SGS		
	177/B		**IT: US/J-PWR integral test** UPTF/SCTF coupling investigation of the two-phase flow behavior in the upper plenum, loops, downcomer and broken cold leg during reflood phase	**Steady state test:** **Double-ended (2A) cold leg break** **Best-estimate (BE) conditions** - Initial pressure: Test vessel: 3.1 bar Containment simulator: 3.2 bar - Initial lower plenum inventory: 51400 kg/s - ECC temperature: 33°C - Broken loop hot leg open: K = 18.2 - All intact loop pump simulators partly open: K = 20 - ECC injection into intact cold legs 1, 2 and 3: 100 kg/s per leg - CS water injection: 157/15-33 kg/s - CS steam injection: 100-82 kg/s - SG behavior simulated		
5			**SET: Downcomer test** Investigation of countercurrent flow limitation in downcomer as well as formation and movement of cold leg water plugs	**Large cold leg break** - Initial pressure: Containment simulator: 2.5 bar - ECC temperature: 30°C - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loops closed at pump simulators - ECC injection into intact cold legs 1, 2 and 3: 500 kg/s per leg - N_2 injection	CD-ROM; binary unit	U9 316/87/17
	062/B			**Initial pressure:** Test vessel: 2.5 bar - Initial lower plenum inventory: 0 kg/s - CS steam injection: 320 kg/s		
	063/A			**Initial pressure:** Test vessel: 18 bar - Initial lower plenum inventory: 13200 kg/s - No CS steam injection		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
6			**SET: Downcomer test** Investigation of countercurrent flow limitation in downcomer, establishing a downcomer flooding curve for saturated emergency core coolant	**Large cold leg break** - Initial pressure: Test vessel: 2.5-2.6 bar Containment simulator: 2.4-2.6 bar - Initial lower plenum water level: 0 m - Slightly subcooled ECC - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loop pump simulators closed -ECC injection into intact cold legs 1, 2 and 3: 490 kg/s per leg - N_2 injection	CD-ROM; binary unit	U9 316/89/2
	131			CS + SGS steam injection: 396 kg/s		
	132			CS + SGS steam injection: 295 kg/s		
	133			CS + SGS steam injection: 202 kg/s		
	135			CS + SGS steam injection: 436 kg/s		
	136			CS steam injection: 102 kg/s		
7			**SET: Dowcomer test** Investigation of countercurrent flow limitation in downcomer for low steam flow rates, determining the effect of ECC injection rates on water penetration, investigation of the effect of loop configuration	**Large cold leg break** - Initial pressure: Test vessel: 2.3-2.5 bar Containment simulator: 2.3-2.6 bar - Initial lower plenum water level: >0.6 m - Slightly subcooled ECC - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loop pump simulators closed - ECC injection into intact cold legs 1, 2 and 3 - No N_2 injection	CD-ROM; binary unit	E 314/90/003
	200/I			- ECC injection into cold leg 1: 494 kg/s - CS steam injection: 104 kg/s		
	200/II			- ECC injection into cold leg 1: 736 kg/s - CS steam injection: 54 kg/s		
	200/III			- ECC injection into cold leg 1: 735 kg/s - CS steam injection: 102 kg/s		
	201/I			- ECC injection into cold legs 2 and 3: 490 kg/s per leg - CS steam injection: 102 kg/s		
	201/III			- ECC injection into cold legs 1- 3: 490 kg/s per leg - CS steam injection: 102 kg/s		
	202/II			- ECC injection into cold legs 2 and 3: 490 kg/s per leg - CS steam injection: 128 kg/s		
	203/I			- ECC injection into cold leg 1: 735 kg/s - CS steam injection: 69 kg/s		
	203/II			- ECC injection into cold leg 1: 737 kg/s - CS steam injection: 30 kg/s		
	203/III			- ECC injection into cold legs 1 and 3: 737 kg/s per leg - CS steam injection: 71 kg/s		
	203/IV			- ECC injection into cold legs 1-3: 490 kg/s per leg - CS steam injection: 51 kg/s		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
8			SET: Flow pattern test Subcooled water plug formation and movement or oscillation in hot and cold legs of loop 2; breakthrough of water plugs through upper tie plate or downcomer	**Large cold leg break** - ECC temperature: 39-49°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 18.2 - Intact loop 1 pump simulators closed - Intact loop 3 pump simulators partly open: K = 18 - No CS water injection - No N_2 injection Subphase I: - ECC injection into cold leg 2: 600/400/250/200/150 kg/s - CS steam injection: 115 kg/s - No SG steam injection	CD-ROM; binary unit	U9 316/88/11
	111/B			**Initial pressure:** Test vessel: 3.8 bar Containment simulator: 3.7 bar - Initial test vessel inventory: 46640 kg - Pump simulator 2 partly open: K = 18 Subphase II: -ECC injection into hot leg 2: 548/419/244/200/150 kg/s - CS steam injection: 165/142/125/118/112/104kg/s - SG behavior simulated		
	112/A			**Initial pressure:** Test vessel: 3.9 bar Containment simulator: 3.9 bar - Initial test vessel inventory: 51370 kg - Pump simulator 2 partly open: K = 10 Subphase II: - ECC injection into hot leg 2: 600/400/250/200/150 kg/s - CS steam injection: 158/136/119/114/109/101 kg/s - SG behavior simulated		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
9			**SET: Flow pattern test** Subcooled water plug formation and movement or oscillation in hot and cold legs of loop 2; breakthrough of water plugs through upper tie plate or downcomer	**Large cold leg break** - Initial pressure: Test vessel: 4.1 bar Containment simulator: 4 bar - ECC temperature: 35-39°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 18.2 - Intact loop 1 pump simulators closed - Steam generator 2 behavior simulated - N_2 injection (partly)	CD-ROM; binary unit	U9 316/88/11
	056/A			**Pump simulators 2 and 3 partly open: K=10** Subphases I and II: - ECC injection into each of hot and cold leg of loop 2: 600/400/250/200/150/100 kg/s Subphase I: - CS steam injection: 141/123/107/104/100/95 kg/s Subphase II: - CS steam injection: 113/93/77/72/68/63 kg/s - CS water injection: 565/477/425/401/381/361 kg/s		
	059/B			**Pump simulators 2 and 3 partly open: K=18** Subphases I and II: - ECC injection into each of hot and cold leg of loop 2: 450/400/250/200/150/100 kg/s Subphase I: -CS steam injection: 116/113/97/91/87/82 kg/s Subphase II: - CS steam injection: 100/93/76/71/67/61 kg/s - CS water injection: 497/475/412/388/371/349 kg/s		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
10	080/A		**SET: Upper core tie plate test** Countercurrent flow limitation at the upper core tie plate for nearly saturated hot leg water injection	**Large hot leg break** - Initial pressure: Test vessel: 3.9 bar Containment simulator: 3.8 bar - Initial test vessel inventory: 10740 kg - ECC temperature: 130°C - Broken loop cold leg closed - Broken loop hot leg fully open: K = 0 - All intact loop pump simulators closed - Steam injection into each of SG simulators 1-3: 5 kg/s - No simulation of SG behavior - No CS water injection - No N_2 injection <u>Subphase I:</u> - ECC injection into hot legs 1 and 3: 100 kg/s per leg - Ramped-down CS steam injection: 187-57 kg/s <u>Subphase II:</u> - ECC injection into hot leg 2: 400 kg/s - Ramped-down CS steam injection: 215-54 kg/s	CD-ROM; binary unit	U9 316/88/3
	081/B		Investigation of entrainment, de-entrainment and water fall back at tie plate and in upper plenum, hot legs and steam generator simulators	**Large cold leg break** Initial pressure: Test vessel: 2.9 bar Containment simulator: 2.9 bar - Initial test vessel inventory: 44580 kg - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 15 - All intact loop pump simulators partly open: K = 15 - CS steam injection: 116/101/78 kg/s - CS water injection: 61/20 kg/s - No ECC injection - No N_2 injection		
	082/C		Countercurrent flow limitation at the upper core tie plate for saturated core simulator steam and water injection	**Large hot leg break** - Initial pressure: Test vessel: 2.6 bar Containment simulator: 2.5 bar - Broken loop cold leg closed - Broken loop hot leg partly open: K=1.4 - All intact loop pump simulators closed - CS steam injection: 81/81 kg/s - CS water injection: 48/148 kg/s - No ECC injection - No SG simulation No N_2 injection		
11	030-034 036-045		**SET: Small break LOCA test** Reflux condensation phenomena; study of countercurrent flow limitation in PWR hot leg	- All loop pump simulators closed - Saturated water injection into the inlet plenum of water separator 4: 30 kg/s (exception: 10 kg/s in Run 037) **Phase B** - Initial pressure: Test vessel: 3.1-3.2 bar - Hot leg of broken loop fully open - CS steam injection: Runs 030-034 resp.: 5/11/13/12/21 kg/s **Phase A** - Initial pressure: Test vessel: 14.8-15.3 bar - Hot leg of broken loop partly open - CS steam injection: Runs 036-045 resp.: 9/8/18/24/31/40/36/34/33/28 kg/s	CD-ROM; binary unit	R 515/87/08

Table 7.18 UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
12	014		**SET: Upper core tie plate test** Countercurrent flow at the upper core tie plate for subcooled hot leg ECC injection; water breakthrough events	**Large hot leg break** - Initial pressure: Test vessel: 6.6 bar Containment simulator: 4.1 bar - Initial water level in lower plenum: 0.94 m - ECC temperature: 26°C - Broken loop cold leg closed - Broken loop hot leg fully open - All intact loop pump simulators closed - ECC injection into hot legs 1-3: 400 kg/s per leg - Ramped-down CS steam injection: 284-156 kg/s - Steam injection in SG simulators 1-3: 15 kg/s per SG - No simulation of SG behavior - No CS water injection - N_2 injection	CD-ROM; binary unit	R 515/86/13
13	071		**SET: Upper core tie plate test** Countercurrent flow at the upper core tie plate for subcooled hot leg ECC injection; CCFL; water breakthrough events; upper plenum pool formation	**Large hot leg break** - Initial pressure: Test vessel: 3.9 bar Containment simulator: 3.8 bar - Initial water level in lower plenum: 1.9 m - ECC temperature: 30°C - Broken loop cold leg closed - Broken loop hot leg fully open - All intact loop pump simulators closed - ECC injection into hot legs 1-3: 400 kg/s per leg - Ramped-down CS steam injection: 245-110 kg/s - Ramped-down CS water injection: 1000-487 kg/s - Steam injection in SG simulators 1-3: 15 kg/s per SG - No simulation of SG behavior - N_2 injection	CD-ROM; binary unit	U9 316/87/22
14	221		**IT: GPWR integral test** Investigation of phenomena in upper plenum, tie plate region, downcomer and loops; water breakthrough events at tie plate and in downcomer; water plug formation and movement in hot and cold legs	**Double-ended hot leg break** **Evaluation model (EM) conditions** **Conditioning phase 17.7-10.5 bar** - Initial pressure: Test vessel: 17.7 bar Containment simulator: 3.9 bar - Initial inventory in lower plenum: 7700 kg - ECC temperature: 31°C - Broken loop cold leg partly open: K=18.2 - Broken loop hot leg: K = 1.4 - All intact loop pump simulators partly open: K=12 - ECC injection into hot legs 2 and 3, and cold legs 1-3 - CS steam injection controlled by feedback system - CS water injection based on CS base steam - SG behavior simulated - N_2 injection - Pressurizer simulation: 78 kg/s steam injection	CD-ROM; binary unit	E 314/90/14

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Siemens
15	123/A		**SET: Upper core tie plate test (hysteresis)** Countercurrent flow at the upper core tie plate for subcooled hot leg ECC injection; CCFL; water breakthrough events; upper plenum pool formation and temperature distribution	**Large hot leg break** Initial pressure: Test vessel: 4.2 bar Containment simulator: 4.2 bar - Initial water level in test vessel: 1.88 m - ECC temperature: 34°C - Broken loop cold leg closed - Broken loop hot leg partly open: K = 1.4 - All intact loop pump simulators closed - ECC injection into hot legs 2 and 3: 405 kg/s per leg - Ramped CS steam injection: 129/61/180 kg/s - Ramped CS water injection: 617/355/823 kg/s - Steam injection in SG simulators 2 and 3: 15 kg/s per SG - No simulation of SG behavior - N_2 injection	CD-ROM; binary unit	U9 316/89/01
	127/B			**Large cold leg break** Initial pressure: Test vessel: 3.7 bar Containment simulator: 3.7 bar - Initial water level in test vessel: 4.85 m - ECC temperature: 31°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 1.4 - All intact loop pump simulators partly open: K = 12 - ECC injection into hot legs 2 and 3: 400 kg/s per leg - Ramped-down CS steam injection: 158-98 kg/s - Ramped-down CS water injection: 650-400 kg/s - SG behavior simulated - N_2 injection		
16			**SET: Upper core tie plate test** Investigation of CCFL at the tie plate under typical GPWR-boundary conditions; water breakthrough events; limits for water breakthrough events; limits for water breakthrough; upper plenum pool formation and temperature distribution	**Large cold leg break** - Initial pressure: Test vessel: 3.8 bar Containment simulator: 3.9 bar - ECC temperature: 31°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 1.4 - All intact loop pump simulators partly open: K = 12 - ECC injection into hot legs 2 and 3: 400 kg/s per leg - Ramped-down CS steam injection: 190-130 kg/s - SG behavior simulated - N_2 injection	CD-ROM; binary unit	E 314/89/22
	181/A			**Initial water level in test vessel: 4.8 m** - Ramped-down CS water injection: 308-225 kg/s		
	184/B			**Initial water level in test vessel: 4.95 m** - Ramped-down CS water injection: 480-338 kg/s		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.2 Type (Characteristics)*		Data base and format	Test data report No. Siemens
17	151		**IT: US/J-PWR integral test** Investigation of two-phase flow behavior in the upper core region, upper plenum, hot and cold legs, steam generator simulators and downcomer during the reflood phase	**Double-ended cold leg break Best-estimate (BE) conditions** Initial pressure: Test vessel: 3.0 bar Containment simulator: 3.0 bar - Initial inventory in lower plenum: 47440 kg - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 1.4 - All intact loop pump simulators partly open: K = 4.5 - Ramped-down CS steam injection: 110-75 kg/s - CS water injection: 160/0 kg/s - No N_2 injection Phase A: - No ECC injection - No simulation of SG behavior Phase B: - ECC injection into intact cold legs 1, 2 and 3: 106 kg/s per leg - ECC temperature: 27°C - SG behavior simulated	CD-ROM; binary unit	E 314/89/20
18	169		**IT: GPWR integral test** Investigation of phenomena in upper plenum, tie plate region, downcomer and loops; water breakthrough events at tie plate and in downcomer; water plug formation and movement in hot and cold legs	**Double-ended cold leg break Evaluation model (EM) conditions** **Conditioning phase 17.7-10.5 bar** Initial pressure: Test vessel: 17.7 bar Containment simulator: 3.9 bar - Initial inventory in lower plenum: 7300 kg - ECC temperature: 37°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 18.2 - All intact loop pump simulators partly open: K=12 - ECC injection into hot legs 2 and 3, and cold legs 1-3 - CS steam injection controlled by feedback system - CS water injection based on CS base steam - SG behavior simulated - N_2 injection - Pressurizer simulation: 78 kg/s steam injection	CD-ROM; binary unit	U9 316/89/11

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.3 Type (Characteristics)*		Data base and format	Test data report No. Siemens
19	192		**IT: GPWR integral test** Investigation of phenomena in upper plenum, tie plate region, downcomer and loops; water breakthrough events at tie plate and in downcomer; water plug formation and movement in hot and cold legs	**Intermediate size cold leg break (0.5A)** **Evaluation model (EM) conditions** **Conditioning phase 17.6-10.5 bar** Initial pressure: Test vessel: 17.6 bar Containment simulator: 3.9 bar - Initial inventory in lower plenum: 24900 kg - ECC temperature: 37°C - Broken loop cold leg partly open: K = 4 - Broken loop hot leg closed - All intact loop pump simulators partly open: K = 12 - Pump simulator of broken loop partly open: K = 31.2 + 18.2 - Ramped-down ECC injection into hot legs 2 and 3 and cold legs 1-3: 482-360 kg/s per leg - CS steam injection controlled by feedback system - CS water injection based on CS steam injection - SG behavior simulated - N_2 injection - Pressurizer simulation by steam injection	CD-ROM; binary unit	U9 316/89/16
20	090		**SET: Upper core tie plate test** Simulation of upper plenum injection of Westinghouse reactors; investigation of CCFL at tie plate; break-through behavior, upper plenum pool formation and entrainment of water into hot legs as well as steam generator simulators	**Large cold leg break** - Initial pressure: Test vessel: 2.6 bar Containment simulator: 2.6 bar - Initial in the test vessel: 4.3 m - ECC temperature: 30°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 8 - Intact loop 1 closed at pump simulator - Pump simulator of intact loops 2 and 3 partly open: K = 8 - ECC injection into hot leg 1: 255 kg/s - CS steam injection: 78/89/74 kg/s - CS water injection: 25/22/25 kg/s - Steam injection in SG simulator 1: 6 kg/s - No simulation of SG behavior - No N_2 injection	CD-ROM; binary unit	U9 316/88/07

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.4 Type (Characteristics)*		Data base and format	Test data report No. Siemens
21	272/A 274/B		**SET: Downcomer injection test** Effect of ECC injection into the downcomer, injection location and subcooling of ECC on water delivery to the lower plenum and ECC bypass Establishment of a base case concerning steam/water interaction in the downcomer for downcomer ECC injection with closed vent valves for comparison with the effects using vent valves; quantification of effects determining the ECC penetration and downcomer flow behavior for two different injection modes, such as downcomer and cold legs	**Large cold leg break** - Initial pressure: Test vessel: 3 bar Containment simulator: 3 bar - Initial lower plenum water level: 0.62 m - Broken loop cold leg fully open - Broken loop hot leg closed - Intact loop pump simulators 1, 2 and 3 closed - Vent valves closed - Thermal sleeves not used - ECC injection directly into downcomer - No N_2 injection Strongly subcooled ECC injection into downcomer : **at 0 and 180°: 910 kg/s per nozzle** - Total CS+SGS injection: 314 kg/s **Subphase I:** - Nearly saturated water injection into downcomer at 0 and 180°: 850 kg/s per nozzle - Total CS+SGS injection: 289 kg/s Subphase II: - Nearly saturated water injection into downcomer at 0: 885 kg/s - CS steam injection: 103 kg/s Subphase III: - Nearly saturated water injection into downcomer at 0 and 180°: 860 kg/s per nozzle - CS steam injection: 102 kg/s	CD-ROM; binary unit	E 314/90/16

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.5 Type (Characteristics)*		Data base and format	Test data report No. Siemens
21			**SET: Downcomer injection test** Establishment of a base case concerning steam/water interaction in the downcomer for downcomer ECC injection with closed vent valves for comparison with the effects using vent valves; quantification of effects determining the ECC penetration and downcomer flow behavior for two different injection modes, such as downcomer and cold legs	**Large cold leg break** Initial pressure: Test vessel: 3.2 bar Containment simulator: 3.2 bar - ECC temperature: 32°C - Broken loop cold leg fully open - Broken loop hot leg open: K = 18.2 - All intact loops partly open at pump simulators: K = 4.5 - Vent valves closed - Thermal sleeve not used - Downcomer ECC injection at 0° and 180°: 508 kg/s per nozzle - CS steam injection: 54/114/163 kg/s - CS water injection: 150/60/85 kg/s		
	273/C			**Initial water level in test vessel: 3.37 m** - No N_2 injection		
	275/C			**Initial water level in test vessel: 3.52 m** - N_2 injection		
	271/D			**Large cold leg break** - Initial pressure: Test vessel: 2.5 bar Containment simulator: 2.5 bar - Initial water level in test vessel: 4.11 m - Initially, saturated downcomer wall - ECC temperature: 30°C - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loops partly open at pump simulators: K = 20 - Vent valves closed - Thermal sleeves not used - Downcomer ECC injection at 0° and 180°: 120 kg/s per nozzle - Steam injection into each SG simulator: 33/29/25/20 kg/s - CS water injection: 270/725 kg/s - No N_2 injection		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.6 Type (Characteristics)*		Data base and format	Test data report No. Siemens
22			**SET: B & W PWR vent valve test** Quantification of effects of ECC injection into the downcomer with <u>open vent valves</u> on the ECC penetration, ECC bypass and flow behavior in the downcomer during end-of-blowdown and reflood	**Large cold leg break** - Initial pressure: Test vessel: 2.8-3.0 bar Containment simulator: 2.8-3.0 bar - Initial water level in test vessel: 0.60-0.64 m - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loops closed at pump simulators - 6 vent valves free-to-open - N_2 injection	CD-ROM; binary unit	E 314/91/008
	280/A			**<u>Subphase I: End-of-blowdown</u>** - ECC injection into downcomer at 0° and 180° resp.: 911/906 kg/s - ECC temperature: 32°C - CS steam injection: 295 kg/s - No CS water injection <u>Subphase II: **Reflood**</u> - ECC injection into downcomer at 0° and 180° resp.: 128/125 kg/s - ECC temperature: 32°C - CS steam injection: 45/86/77/77/66 kg/s - CS water injection: 170/50/100/50/70 kg/s - No N_2 injection		
	281/B			**ECC injection into downcomer** at 0° and 180° resp.: 881 kg/s per nozzle - ECC temperature: 121°C - CS steam injection: 198 kg/s		
	282/C			**ECC injection into downcomer** at 0° and 180°: 872 kg/s per nozzle - ECC temperature: 120°C - CS steam injection: 224 kg/s - SG simulator steam injection: 89 kg/s		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.7 Type (Characteristics)*		Data base and format	Test data report No. Siemens
22			**SET: B & W PWR vent valve test** Quantification of effects of ECC injection into the downcomer with <u>open vent valves</u> on the ECC pene-tration, ECC bypass and flow behavior in the downcomer during end-of-blowdown and reflood	**Large cold leg break** - Initial pressure: Test vessel: 2.8-3.0 bar Containment simulator: 2.8-3.0 bar - Initial water level in test vessel: 0.6-0.64 m - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loops closed at pump simulators - 6 vent valves free-to-open - N_2 injection		
	283/B			**ECC temperature: 122°C** - CS steam injection: 105 kg/s <u>Subphase I:</u> - ECC injection into downcomer at 0°: 883kg/s <u>Subphase II:</u> - ECC injection into downcomer at 0° and 180° resp.: (45)/884 kg/s <u>Subphase III:</u> - ECC injection into downcomer at 0° and 180° resp.: 880 kg/s per nozzle		
	284/C			**ECC injection into downcomer** at 0° and 180° resp.: 865/860 kg/s - ECC temperature: 122°C - CS steam injection: 207 kg/s - SGS steam injection: 88 kg/s - Thermal sleeves mounted		
	285/B			**ECC injection into downcomer** at 0° and 180° resp.: 872/869 kg/s - ECC temperature: 123°C - CS steam injection: 197 kg/s - Thermal sleeves mounted		
23	290/B		**SET: B & W PWR vent valve test** Determination of ECC carry over at the break for ECC injection into the downcomer with <u>open vent valves</u>; estimation of de-entrainment in the upper plenum; quantification of flow behavior in the downcomer	**Large cold leg break** - Broken loop cold leg fully open - Vent valves free to open - Thermal sleeves mounted - ECC temperature: 34°C **Initial pressure:** Test vessel: 2.4 bar Containment simulator: 2.4 bar - Initial water level in the test vessel: 5.1 m - Broken loop hot leg closed All intact loops closed at pump simulators - ECC injection into downcomer at 0° and 180° resp.: 120 kg/s per nozzle	CD-ROM; binary unit	E 314/90/25

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.8 Type (Characteristics)*		Data base and format	Test data report No. Siemens
	291/A			- CS water injection: 218/260/302 kg/s - Step-wise steam injection into each of SGS 1-3: 32/29/26/20 kg/s - No N_2 injection **Initial pressure:** Test vessel: 3.5 bar Containment simulator: 3.5 bar Initial water level in the test vessel: 4.2 m - Broken loop hot leg partly open: K = 18.2 - All intact loops partly open: K = 4.5 - ECC injection into downcomer at 0° and 180° resp.: 510 kg/s per nozzle - CS steam injection: 76/127/168 kg/s - CS water injection: 161/66/90 kg/s - No SG simulation - No CS water injection - N_2 injection		
24	302/ 304		**SET: B & W PWR vent valve test** Investigation of following phenomena: - effect of vent valves on ECC bypass in the downcomer during depressurization - ECC entrainment from the downcomer to the break and ECC de-entrainment in the upper plenum during reflood - pressure drop across vent valves and ECC flow path in the cold legs as a function of time	**Double-ended cold leg break** - Initial pressure: Test vessel: 17.8 bar Containment simulator: 3.3 bar - Initial water level in the test vessel: 0.6/0.66 m at 207°C - ECC temperature: 30/33°C - 6 vent valves free-to-open - Broken loop cold leg fully open - Broken loop hot leg open: K = 18.2 - All intact loops open at pump simulators: K=4.5 - ECC injection in cold leg 2: 360/362 kg/s - ECC injection into downcomer: 1100/1159 kg/s (at 0°) 1120/1205 kg/s (at 180°) - CS steam and water injected according to water breakthrough - Steam injection into each of SG simulators: 35/31 kg/s - N_2 injection (except for DC injection) - Pressurizer simulation	CD-ROM; binary unit	E 314/90/22

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.9 Type (Characteristics)*		Data base and format	Test data report No. Siemens
25			**SET: Downcomer test**	**Large cold leg break** - Initial water level in test vessel: 3.95 m - Broken loop cold leg fully open - Broken loop hot leg closed - Vent valves closed - Thermal sleeves not used - All intact loop pump simulators partly open: K = 20 - No CS steam and water injection - No N_2 injection	CD-ROM; binary unit	E 314/90/13
	241/B		Investigation of water level/entrainment in downcomer with saturated downcomer wall and cold leg flow regime	**Initial pressure:** Test vessel: 2.3 bar Containment simulator: 2.4 bar - Initially, saturated downcomer wall - ECC injection into each of three cold legs 1-3: 117/80/140 kg/s - ECC temperature: 28°C - Steam injection into each of SG simulators 1-3: 23/30/23/17/10 kg/s		
	242/A		Investigation of water level/entrainment in downcomer with superheated downcomer wall	Initial pressure: **Test vessel: 2.4 bar** **Containment simulator: 2.5 bar** - Initially, superheated downcomer wall - ECC injection into each of three cold legs 1-3: 117/80/80 kg/s - ECC temperature: 29°C - Steam injection into each of SG simulators 1-3: 23/30/25/20/15 kg/s		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.10 Type (Characteristics)*		Data base and format	Test data report No. Siemens
26			**SET: Flow pattern test** Investigation of water plug formation and movement or oscillation in hot legs; breakthrough events of water plugs through upper tie plate	**Large cold leg break** - Initial pressure: Test vessel: 3.8 bar Containment simulator: 3.9 bar - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 3.9 - No CS water injection - No simulation of SG behavior - No N_2 injection	CD-ROM; binary unit	E 314/91/003
	230/A		Effect of water temperature (saturated water) on flow regime in injecting broken loop hot leg	**Initial test vessel inventory: 17690 kg** - All intact loops closed at pump simulators - ECC injection into broken loop hot leg: 150/395 kg/s - ECC temperature: 141°C - CS steam injection: 7/14/18/22/10/19/27/29 kg/s		
	231/B		Effect of water temperature (subcooled water) on flow regime in injecting hot leg of loop 2	**Initial test vessel inventory: 48320 kg** - Intact loop 1 closed at pump simulators - Pump simulators 2 and 3 partly open: K = 10 and 18 resp. - ECC injection into hot leg 2: 150/400 kg/s - ECC temperature: 30°C - CS steam injection: 73/108/121/140/24/129/162/78kg/s		
	232/C		Effect of water temperature (subcooled water) on flow regime in injecting hot legs of loops1, 2 and 3	**Large cold leg break** - Initial pressure: Test vessel: 3.9 bar Containment simulator: 3.9 bar - Initial test vessel inventory: 59240 kg - ECC temperature: 27-31°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 3.9 - All intact loops partly open at pump simulators: K = 4.5 - ECC injection into hot legs 1-3: 380 kg/s per leg - CS steam injection: 107 kg/s - CS water injection: 975 kg/s - No simulation of SG behavior - N_2 injection		

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.11 Type (Characteristics)*		Data base and format	Test data report No. Siemens
27	255/B 256/A		**IT: US/J-PWR integral test** Investigation of steam/water flow phenomena in the US/J-PWR during end-of-blowdown (EOB), refill and reflood phases of a double-ended cold leg break, esp.: - Flashing and entrainment of water in the lower plenum, steam/water countercurrent flow behavior in the downcomer during EOB and refill - Two-phase flow behavior in the upper plenum, downcomer and loops during reflood	**Double-ended cold leg break** **Best-estimate (BE) conditions** **Phase B (Reflood):** - Initial pressure: Test vessel: 2.5 bar Containment simulator: 2.5 bar - Initial inventory in test vessel: 46726 kg at 128°C - ECC temperature: 30°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 18.2 - All intact loop pump simulators partly open: K = 9.7 - ECC injection into intact cold legs 1, 2 and 3: 647/163 kg/s (2 subphases) - CS steam injection: 147 kg/s - CS water injection: 158 kg/s - Steam injection into each SG simulator: 12 kg/s - N_2 injection **Phase A (EOB and Refill):** - Initial pressure: Test vessel: 11.6 bar Containment simulator: 2.3 bar - Initial inventory in test vessel: 7778 kg at 188°C - ECC temperature: 33°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 8.8 - All intact loop pump simulators partly open: K = 8.8 - ECC injection into intact cold legs 1, 2 and 3: 390/452/80 kg/s (3 subphases) - CS steam injection: 106 kg/s - CS water injection: 160 kg/s - SG behavior simulated - N_2 injection	CD-ROM; binary unit	E 314/90/26
28	262		**IT: GPWR integral test** Investigation of steam/water flow phenomena in GPWR with combined ECC injection during end-of-blowdown, refill and reflood phases following a LOCA with double-ended cold leg break; especially distribution of water downflow at the tie plate and local steam condensation during EOB and refilling of lower plenum, and ECC flow behavior in the upper plenum and at the tie plate and consequently steam condensation in the primary system during reflood	**Double-ended cold leg break** **Best-estimate (BE) conditions** **Conditioning phase 17.7-10.5 bar** Initial pressure: Test vessel: 17.7 bar Containment simulator: 3.9 bar - Initial inventory in lower plenum: 7650 kg - ECC temperature: 28-30°C - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 18.2 - All intact loop pump simulators partly open: K = 12 - Ramped-down ECC injection into each of 4 hot legs and of cold legs 1-3: 557-435 kg/s (except hot legs 1 and 4, initial value 516 kg/s) - CS steam injection controlled by feedback system - CS water injection based on CS base steam - SG behavior simulated - N_2 injection (except broken HL injection) - Pressurizer simulation: 72 kg/s steam	CD-ROM; binary unit	E 314/90/08

UPTF 2D/3D Test matrix (part 1) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.12 Type (Characteristics)*		Data base and format	Test data report No. Siemens
29	210/A 211 212/B		**SET: Entrainment and de-entrainment test** Investigation of entrainment and de-entrainment in upper plenum and water fall back at tie plate, water accumulation in upper plenum; liquid carry over to hot legs and steam generator simulators	**Large cold leg break** - Initial water level in test vessel: 4.15 m - Broken loop cold leg fully open - Broken loop hot leg partly open: K = 3.9 - All intact loop pump simulators partly open: K = 4.5 - No ECC injection - No SG behavior simulated - N_2 injection **Initial pressure:** Test vessel: 3.1 bar Containment simulator: 3.1 bar - CS steam injection (3 subphases): 107/104/106-80 kg/s - CS water injection (3 subphases): 405/255/608-350-369-502 kg/s **Initial pressure:** Test vessel: 2.8 bar Containment simulator: 2.9 bar - CS steam injection (6 subphases): 103/86/102/87/101/87 kg/s - CS water injection (6 subphases): 147/162/98/113/59/74 kg/s	CD-ROM; binary unit	E 314/90/19
30	141/A 142/B		**SET: Upper core tie plate test** High pressure injection simulation; condensation efficiency in hot legs, upper plenum and tie plate region; phenomena at tie plate and breakthrough behavior for small injection rates; upper plenum pool formation	- Initial pressure: Test vessel: 15 bar Containment simulator: 3 bar - Hot and cold leg break valves closed (bypass valves open) - Intact loop 3 closed at pump simulator - Pump simulators of intact loops 1and 2 partly open: K = 10 - Ramped-up CS steam injection: 35-70 kg/s - No CS water injection - No N_2 injection **Initial water level in test vessel: 4.15 m** - ECC injection into hot leg 2: 80/60/40/30 kg/s - ECC temperature: 33°C **Initial water level in test vessel: 3.95 m** - ECC injection into hot legs 1 and 2: 43/34 kg/s - ECC temperature: 31°C	CD-ROM; binary unit	E 314/89/22

UPTF 2D/3D Test matrix (part 2)

Test matrix No.	Exp. I.D.	Date	*2.3.10.13 Type (Characteristics)*		Data base and format	Test data report No. Siemens
Z1	310 311 312 313		**SET: Downcomer test** Investigation of water level/entrainment in downcomer with saturated downcomer wall and cold leg flow regime	**Large cold leg break** - Initial water level in test vessel: 3.95 m - Broken loop cold leg fully open - Broken loop hot leg closed - Vent valves closed - Thermal sleeves not used - All intact loop pump simulators partly open: K = 15 - No CS steam and water injection (only for water level adjustment) - No N_2 injection - Initial pressure Test vessel: 2.6 bar Containment simulator: 2.6 bar - Initially, saturated downcomer wall - ECC injection into each of three cold legs 1-3: /80/110/10 kg/s - ECC temperature: 30 –35.5°C Steam injection into each of SG simulators 1-3: 10/15/20/25/30/ kg/s - Water level in Test vessel: 4.4 - 4.9m	CD-ROM; binary unit	NT31/99/65
Z2	343		**IT: US/J-PWR integral test** Investigation of steam/water flow phenomena in the US/J-PWR during end-of-blowdown (EOB), refill and reflood phases of a double-ended cold leg break, esp.: - Flashing and entrainment of water in the lower plenum, steam/water countercurrent flow behavior in the downcomer during EOB and refill - Two-phase flow behavior in the upper plenum, downcomer and loops during reflood	**Double-ended cold leg break** **Best-estimate (BE) conditions** - Initial pressure: Test vessel: 12.0 bar Containment simulator: 2.4 bar - Initial water level in test vessel: 1.5m at 128°C - ECC temperature: 25°C - Broken loop hot and cold leg closed at beginning of test - Broken loop hot leg partly open: K = 8.3 during test - Broken loop cold leg fully open during test - All intact loop pump simulators partly open: K = 8.8 - ECC injection into intact cold legs 1, 2 and 3: 647/80 kg/s - CS steam injection: f(t) - CS water injection: f(t) - Steam injection into each SG simulator: 12 kg/s	CD-ROM; binary unit	NT31/99/75
Z3	321 322 323 324 325 326 327 328 329		**SET: Downcomer test** Investigation of countercurrent flow limitation in downcomer, establishing a downcomer flooding curve for emergency core coolant. The main objective was to study the effect of pressure.	**Large cold leg break** - Initial pressure: Test vessel: 2.4-8.1 bar Containment simulator: 2.4-5.3 bar - **Initial lower plenum water level: 0.6- 1.5 m** - ECC temp. 34 °C or slightly subcooled - Broken loop cold leg fully open - Broken loop hot leg closed - All intact loop pump simulators closed – ECC injection into intact cold legs 1, 2 and 3 or in cold leg 1 only between 385 and 775 kg/s - N_2 injection in some tests	CD-ROM; binary unit	NT31/99/48

UPTF 2D/3D Test matrix (part 2) – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.14 Type (Characteristics)*		Data base and format	Test data report No. Siemens
Z4	**330** **331** **332** **333** **334**		**SET: Entrainment and de-entrainment test** Investigation of entrainment and de-entrainment in upper plenum and water fall back at tie plate, water accumulation in upper plenum; liquid carry over to hot legs and steam generator simulators	**Large cold leg break** - Initial water level in test vessel: 4.15 m - Broken loop cold leg fully open - Broken loop hot leg fully open - All intact loop pump simulators partly open: K = 4.5 - No ECC injection - No SG behavior simulated A) N_2 injection B) Initial pressure: Test vessel: 2.8 bar Containment simulator2.8 bar - CS steam injection: 90/100/120kg/s - CS water injection: 60/100/140/180 kg/s	CD-ROM; binary unit	NT31/99/70

UPTF TRAM Test Matrix

Test matrix No.	Exp. I.D.	Date	*2.3.10.15 Type (Characteristics)*		Data base and format	Test data report No. Siemens
A1	01a 02a 03a 03b 04a		Investigation of the spatial distribution of high-pressure hot-leg injected ECC delivered to the core at counterflow of steam and water from the core during a cold leg SBLOCA	- All intact loop pump simulators partly open: K = 4.5 - ECC injection into all 4 hot legs: 40 kg/s - Initial pressure: Test vessel: 3/15 bar Containment simulator 3/5/5.2 bar - CS steam injection: 37/38/50/60/75/97/122kg/s - CS water injection: 0/164/180/395/406	CD-ROM; binary unit	NT33/95/013
A2	01a 01b 02b 03c 04c 04d		Investigation of the flow regimes in the hot leg of a pressurized water reactor under two-phase natural circulation conditions	- All loop pump simulators closed - Broken loop cold leg closed - Broken loop hot leg fully open - Initial pressure: Test vessel: 3/5/15 bar Containment simulator 1.6/2.1/5/bar - CS steam injection: 2.5/4/5/6/7/8/10/16/20/25/32/39 kg/s - CS water injection: 0/100/150/288/315/392/425/435 kg/s	CD-ROM; binary unit	S 554/92/012
A3	01a 02a 03a 04a 05b 06a 07b		Investigation of the interaction between the hot leg injected ECC and single-phase or two-phase natural circulation in the hot leg in the case of an SBLOCA in a PWR	- All loop pump simulators closed - Broken loop cold leg closed - Broken loop hot leg fully open - Initial pressure: Test vessel: 3/15 bar Containment simulator 1.6/5/bar - CS steam injection: 4.1/4.6/7.4/10.3 kg/s - CS water injection: 15/36/50/74/88/100/120/132/155/160/ 195/236/286/350 kg/s - ECC injection into hot leg 4: f(t) max 315 kg/s; min 40 kg/s	CD-ROM; binary unit	NT33/95/004
A4	01a 02a 03e 04a 05a 06b		Investigation of the reflux condenser mode of operation of a pressurized water reactor under SCLOCA conditions	- pump simulators in loop 1 and 3 partly open: K = 4.5 - pump simulator in loop 2 closed - Broken loop cold leg closed - Broken loop hot leg fully open (ζ = 1.4) - injection of saturated water (reflux condenser simulation) into the entrance chamber of SG 4 - Initial pressure: Test vessel: 3/15 bar Containment simulator 2/5 bar - CS steam injection: 8.5/9.5/13/15/17/20/25/30/35/40/45 kg/s - ECC injection into hot leg 4: 20/35/40 kg/s	CD-ROM; binary unit	E 314/92/003

UPTF TRAM Test Matrix – cont.ed

Test matrix No.	Exp. I.D.	Date	*2.3.10.16 Type (Characteristics)*		Data base and format	Test data report No. Siemens
A5	01a- 10a 11e 11d IT01b IT02a		Investigation of the PWR loop seal clearing	Separate effect tests - Pump simulators in loop 1,2 and 4 closed - Pump simulator in loop 2 partly open K = 18 - Broken loop cold leg = f(p,t) - Broken loop hot leg closed) - Initial pressure: Test vessel: 3/15 bar Containment simulator 3 bar - Steam injection into SG 2 =f(t) Integral tests - Pump simulators in all loops partly open K = 18 - Broken loop cold leg = simulation of leak (2,9 % (IT01b); 4.4 % (IT02a)) - Broken loop hot leg closed) - Initial pressure: Test vessel: 15 bar Containment simulator 3 bar - CS steam injection:40 kg/s	CD-ROM; binary unit	NT33/94/011
A6 A7	01c 02a 03a 04a 01a 02a		Investigation of the effectiveness of ECC injection from accumulators into the cold or hot legs during an intermediate-size cold leg break of a PWR (1300 MWe) in the full-scale test facility UPTF at pressure scaled boundary conditions	- Pump simulators in all loops partly open: K = 18 - Broken loop cold simulation of leak - Broken loop hot leg closed - Initial pressure: Test vessel: 16 bar Containment simulator 3 bar - CS steam injection: 30 – 60 kg/s - ECC injection into all 4 hot legs =f(t) - ECC injection into all 4 cold legs =f(t)	CD-ROM; binary unit	NT33/95/009
B B1a B1b	01a 02a 01a 02a 03c		Investigation of the loss of feed-water supply transient in a PWR followed by accident management procedures including primary bleed and feed. For this tests a original surge line and a pressurizer were installed in the UPTF	- The course of the accident transient ***beginning at net steam production at the core outlet and continued until the water level degraded to about the lower edge of the primary coolant line*** was simulated	CD-ROM; binary unit	NT31/96/04
B2	01c 02b 03a 04b 05g 06a			- An accident transient – depressurization by intentional opening of pressurizer (PR) relief valves – from the activating of PR-relief valves to the activating pressure of ECC accumulators was simulated under pressure-scaled boundary conditions. Flow phenomena in the primary system , surge line and pressurizer are investigated	CD-ROM; binary unit	NT31/96/21

UPTF TRAM Test Matrix – cont.ed

Test matrix No.	**Exp. I.D.**	**Date**	***2.3.10.17 Type (Characteristics)***		**Data base and format**	**Test data report No. Siemens**
B3	01a 02b 03a 04b 05b 06a- 10a 11b			- An accident transient – depressurization by intentional opening of pressurizer (PR) relief valves – continuing at the activation pressure of EC accumulators- was simulated under pressure-scaled boundary conditions. Flow phenomena in the primary system surge line and pressurizer are investigated	CD-ROM; binary unit	NT31/96/39
B4a	01a 02a					
B4b	01a- 04a					
C1	01a 02a1 02a4 02b4 03a2 03a3 03b1 04a1 04a2 05a1 05a23 12a3 21a2		Investigation of the fluid-fluid mixing and condensation phenomena in the cold legs and downcomer associated into the water or steam filled cold legs. These mixing and condensation phenomena determine the global cooldown and the fluid temperature distribution in the downcomer and are thus important boundary conditions for the thermal shock related fracture mechanical analysis of the RPV	- Fluid-fluid mixing in the cold leg and in the downcomer	CD-ROM; binary unit	NT31/96/17
C2	06a 06b 07a 08a 08b 09a			- Direct contact condensation in the cold legs - ECC-water strip trajectories and ECC-water strip temperature near test vessel wall		
C3	10b 11a 12b 13a 14a		Investigation of the mixing of low borated condensate with the highly-borated ambient water during reflux condenser mode of operation following an SBLOCA.	Following test parameters were varied: - ECC water injection rate - Initial water temperature in downcomer and lower plenum - Temperature and rate of the injecting hot water (condensate)	CD-ROM; binary unit	NT31/96/41
D	01b 01c 02a- 07a 10a- 14a 13b		Investigation of the flow phenomena during the total loss of coolant in the primary system of a PWR in the case of a beyond-basis design accident.	The energy redistribution in the primary system due to air circulation flow was experimentally studied in UPTF under geometrical full-scale PWR conditions applying air flow at atmospheric pressure: C) Loop configuration: all 4 hot legs or hot leg 2 only	CD-ROM; binary unit	NT31/96/60

Table 24 - **PIPER-ONE Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Pisa Univ.
1	PO-SD-1	11/09/97	Characterization	Behavior of PS Efficiency of control systems	Old tape cartridge/paper	RL300(87) NT081(87)
2	PO-SD-2/I	11/09/87	Characterization	As above	Old tape cartridge/paper	NT092(87)
3	PO-SD-2/II	12/04/87	Characterization	As above. Heat losses measurement Instrumentation and DAS behavior	Old tape cartridge/paper	
4	PO-SD-3	03/01/88	Characterization	As above PC control Gas pressure control	Old tape cartridge/paper	NT110(88)
5	PO-SD-4/I	04/28/88	Nat. Circ.	Single phase NC	Old tape cartridge/paper	RL411(89) RL421(89)
6	PO-SD-4/II	05/10/88	Nat. Circ.	Two phase NC	Old tape cartridge/paper	RL412(89) RL452(89)
7	PO-SD-5/A	06/14/89	Instability	Stability of NC (Low power/high pressure)	CD-ROM; text file	NT132(89)
8	PO-SD-5/B	06/14/89	Instability	Stability of NC (High power/low pressure)	Old tape cartridge/paper	
9	PO-SD-6/A	12/17/90	Reflood	Evaluation of GDCS performance	Old tape cartridge/paper	NT164(90)
10	PO-SD-6/B	12/18/90	Reflood	As above	Old tape cartridge/paper	
11	PO-SD-6/C	12/19/90	Reflood	As above	Old tape cartridge/paper	
12	PO-SB-7	03/25/88	SBLOCA Ar=2.6% LDC	ISP 21 Scaling assessment	CD-ROM; text file	RL340(88) RL381(89) RL386(89)
13	PO-SB-7C	07/21/88	SBLOCA Ar=2.6% LDC	Influence of SCS	Old tape cartridge/paper	NT111(88) RL404(89) RL410(89)
14	PO-SB-1	08/02/89	SBLOCA Ar=2.6% SD	Efficiency HPCS	Old tape cartridge/paper	NT121(88) NT172(91)
15	PO-SB-2	06/07/89	SBLOCA Ar=2.6% SD	Break position effect	Old tape cartridge/paper	RL365(88) RL424(89)
16	PO-SB-3	05/08/89	SBLOCA Ar=2.6% SD	Delayed ADS	Old tape cartridge/paper	NT173(91)
17	PO-IB-1	12/07/89	IBLOCA Ar=16% SD	Break area effect	Old tape cartridge/paper	RL406(89) RL455(90)
18	PO-IB-1C	06/06/90	IBLOCA Ar=16% SD	Influence of SCS	Old tape cartridge/paper	NT148(89) RP484(90)
19	PO-LB-1	07/10/90	LBLOCA Ar=200% DC	Multiple failure Reflood in LBLOCA	Old tape cartridge/paper	NT157(90)
20	PO-SD-8/A	02/11/92	Core cooling	IC performance at low pressure	Old tape cartridge/paper	NT190(92)
21	PO-SD-8/B (*)	02/11/92	Core cooling	IC performance at high pressure		
22	PO-SD-8/C	02/11/92	Core cooling			
23	PO-SD-8/D	02/11/92	Core cooling			

(*) The following phases were carried out in sequence at higher power

PIPER-ONE Test Matrix – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. Pisa Univ.
24	PO-IC-2/A/I	10/04/94	Core cooling	As previous test with improved IC instrumentation	CD-ROM; text file	NT234(94) NT254(95)
25	PO-IC-2/A/II	10/04/94	Core cooling	Phase carried out in sequence at higher power		
26	PO-IC-2/B	10/04/94	Core cooling	Influence of N2 injection on IC performance (power as in phase A)		
27	PO-IC-3/A (*)	04/27/95	Core cooling	As for the first test with air above IC at test beginning	CD-ROM; text file	NT243(94)
28	PO-IC-3/B	04/27/95	Core cooling	Influence of a break opening in LDC		
29	PO-IC-3/C	04/27/95	Core cooling	Influence of FW injection to recover normal conditions		
30	PO-IC-3/D	04/27/95	Core cooling	Influence of N2 injection at low pressure		
31	-	01/13/97	Geysering	Boiling system instability evaluation	to be analyzed	NT207(93)
32	-	01/14/97	Geysering	Boiling system instability evaluation	to be analyzed	
33	-	01/15/97	Geysering	Boiling system instability evaluation	to be analyzed	
34	-	01/15/97	Geysering	Boiling system instability evaluation	to be analyzed	

(*) the following phases were carried out in sequence at higher power

Table 25 - **PACTEL Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. VTT
-	HL01 - HL16	-	Heat losses	ASCII and binary on DAT-tape	PROPA 10/92
-	NC01 - NC07	-	Natural circulation	ASCII and binary on DAT-tape	-
-	CPR01 - CPR04 CPR11 - CPR12	-	Depressurisation of Primary System	ASCII and binary on DAT-tape	PROPA 11/91 PROPA 3/92 TEKOJA 1/97
-	ITE01 - ITE10	-	ISP-33	ASCII and binary on DAT-tape	NEA/CSNI/R(94)24 Part I and II
-	SBL02 - SBL12 SBL20 - SBL22 SBL30 - SBL33 SBL40	-	SBLOCA	ASCII and binary on DAT-tape	PROPA 13/92 TEKOJA 4/96 TEKOJA 6/96 TEKOJA 3/97 TEKOJA 4/98 TEKOJA 5/97
-	LOF01 - LOF04 LOF10	-	Loss of Secondary-side Feed Water	ASCII and binary on DAT-tape	PROPA 8/93 PROPA 11/94 TEKOJA 7/97 TEKOJA 7/98
-	CMP01 - CMP11	-	Compensated SBLOCA	ASCII and binary on DAT-tape	PROPA 16/92
-	GDE01 - GDE05 GDE11 - GDE14 GDE21 - GDE25 GDE31 - GDE35 GDE41 - GDE45	-	Gravity Driven ECC	ASCII and binary on DAT-tape	PAHKO 2/96 PAHKO 2/97 PAHKO 3/97 PAHKO 7/97 PAHKO 2/98 PAHKO 3/98 PAHKO 6/98
-	LSR01 - LSR02 LSR10 LSR20 - LSR21	-	Hot Leg CCFL	ASCII and binary on DAT-tape	PROPA 13/92
-	PSL01 - PSL07 PSL10 - PSL11	-	Primary to Secondary Leakage	ASCII and binary on CD-R	PROPA 6/94 TEKOJA 5/95 TEKOJA 5/96 TEKOJA 8/96 TOKE 5/99 TOKE 2/2000
-	SIR01 - SIR02 SIR10 - SIR11	-	Stepwise inventory reduction test	ASCII and binary on DAT-tape	PROPA 13/92
-	SIR20 - SIR23	-	Natural circulation tests in low primary pressure	ASCII and binary on DAT-tape	TEKOJA 4/95
-	ATWS01 - ATWS06 ATWS10 - ATWS13 ATWS20 - ATWS21 ATWS32	-	ATWS-experiments	ASCII and binary on CD-R	TEKOJA 2/97 TEKOJA 6/97 TEKOJA 1/98 TOKE 2/99
-	RUN1 - RUN3 NCG01 - NCG03	-	Non condensable gas experiments	ASCII and binary on DAT-tape	TEKOJA 6/98

PACTEL Test Matrix – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. VTT
-	FLT01 (R1 - R24)	-	Pressure losses	ASCII on DAT-tape	TOKE 7/99
-	HPR01 - HPR13 (*)	-	Emergency feed water experiments	ASCII and binary on DAT-tape	TEKOJA 10/95
-	SG01 - SG05 HSG01 - HSG03 (*)	-	Steam generator experiments	ASCII and binary on DAT-tape	PROPA 1/94

(*) HPR and HSG experiment data is not publicly available

Table 26 - **PMK Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)			Data base and format (*)	Test data report No KFKI.
			Initiating event	ECCS config.	Remark		
1	CLB1	86	7,4 % CLB-LOCA	0 SIT, 1 HPIS		ASCII files	
2	CLB2	87	7,4 % CLB-LOCA	0 SIT, 0 HPIS		ASCII files	
3	CLB3	87	7,4 % CLB-LOCA	3 SIT, 1 HPIS		ASCII files	
4	CLB4	87	7,4 % CLB-LOCA	3 SIT, 1 HPIS		ASCII files	
5	CLB5	88	7,4 % CLB-LOCA	3 SIT, 1 HPIS	HL-CL connected	ASCII files	
6	CLB10	92	7,4 % CLB-LOCA	3 SIT, 0 HPIS, 1 LPIS	Sec. F&B	ASCII files	
7	CLB11	92	7,4 % CLB-LOCA	3 SIT, 0 HPIS	NKG0 Sec. B	ASCII files	
8	CLB12	92	7,4 % CLB-LOCA + gas	3 SIT, 0 HPIS	NKG1 Sec. B	ASCII files	
9	CLB13	93	7,4 % CLB-LOCA + gas	3 SIT, 0 HPIS	NKG2 Sec. B	ASCII files	
10	CLB14	93	7,4 % CLB-LOCA	3 SIT, 0 HPIS, 1 LPIS	Sec. F&B	CERTA database	
11	CLB19	99	7,4 % CLB-LOCA	3 SIT, 0 HPIS, 1 LPIS	Prim. F&B, Sec. B	ASCII files	
12	HLB1	89	7,4 % HLB-LOCA	0 SIT, 1 HPIS		ASCII files	
13	HLB2	89	7,4 % HLB-LOCA	3 SIT, 1 HPIS		ASCII files	
14	HLB3	96	1,0 % HLB-LOCA, PRZSV	2 SIT, 1 HPIS		ASCII files	
15	HLB4	97	22 % HLB-LOCA, surge line	2 SIT, 1 HPIS, 1 LPIS		ASCII files	
16	PRISE1	88	GF coll. lift-up	0 SIT, 1 HPIS		ASCII files	
17	PRISE2	89	GF coll. lift-up	3 SIT, 2 HPIS		CERTA database	
18	PRISE3	97	GF coll. lift-up	0 SIT, 1 HPIS	SGSV stuck open	ASCII files	
19	PRISE4	98	GF coll. lift-up	4 SIT, 2 HPIS	Sec. F&B	ASCII files	
20	PRISE5	98	SGTR 10 tubes	4 SIT, 2 HPIS	Sec. F&B	ASCII files	
21	PRISE6	98	SGTR 3 tubes	(4 SIT), 2 HPIS	Sec. F&B	ASCII files	
						ASCII files	
22	CLB6	89	3,5 % CLB-LOCA	0 SIT, 1 HPIS		ASCII files	
23	CLB7	90	14,8 % CLB-LOCA	0 SIT, 1 HPIS		ASCII files	
24	CLB8	90	14,8 % CLB-LOCA	3 SIT, 1 HPIS		ASCII files	
25	CLB9	90	1,0 % CLB-LOCA	0 SIT, 1 HPIS		ASCII files	
26	CLB15	94	1,0 % CLB-LOCA	0 SIT, 1 HPIS		ASCII files	
27	CLB16	95	1,0 % CLB-LOCA	0 SIT, 1 HPIS	Prim. F&B	ASCII files	
28	CLB17	99	0,5% CLB-LOCA	0 SIT, 3 HPIS	overfed	ASCII files	
29	CLB18	99	2,0 % CLB-LOCA	2 SIT, 0 HPIS	Sec. F&B	ASCII files	
						ASCII files	
30	NATC1	88	natural circ.			ASCII files	
31	NATC2	93	natural circ.	TCG1-12		ASCII files	
32	NATC3	93	natural circ. + gas	GFK1		ASCII files	
33	NATC4	93	natural circ. + gas	FET1		ASCII files	
34	NATC5	93	natural circ. + gas	GKK		ASCII files	
35	NATC6	93	natural circ.	HVM1-3		ASCII files	
36	NATC7	98	natural circ.+gas	GFK2 (GUP)		ASCII files	
37	NATC8	98	natural circ.+gas	FET2		ASCII files	
38	NATC9	98	heat sink degr.	lowered sec. lev.	BRU-A opening	ASCII files	
						ASCII files	
39	LOF66	86	MCP trip 6/6			ASCII files	
40	LOF41	87	MCP trip 4/1-6/1			ASCII files	
41	TLFW1	87	loss of feedw.			ASCII files	
42	TLFW2	92	loss of feedw.		Sec. F&B	ASCII files	
43	TLFW3	96	loss of feedw.		Prim. F&B	ASCII files	
44	MSHB	93	main steam header b.		Sec. F&B	ASCII files	
45	STB1	92	loss of power		Sec. F&B	ASCII files	
46	STB2	97	loss of power		Prim. F&B	ASCII files	
47	STB3	99	loss of power + ATWS		boron conc. 1 HPIS	ASCII files	
48	STB4	99	loss of power + ATWS		boron conc. 1 HPIS	ASCII files	

Table 27 - **FIX-II LOCA Experiments**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. STUDSVIK
1	3013	1983-05-05	31% split break. Average channel power.	Paper plots only of all quantities in SI units	NR-83/316
2	3024	1983-04-24	31% split break. Hot channel power.	-"-	NR-83/317
"	3025	1983-05-04	-"-, duplicate test of reproducibility.	Paper plots + electronic. ASCII format, time vs. variable, 48 Hz/channel	NR-83/318
"	3026	1984-05-15	-"-	Paper plots only of all quantities in SI units	NR-84/484
"	3027	1984-05-17	-"-	-"-	NR-84/485
3	3031	1983-05-10	48% split break. Hot channel power.	-"-	NR-83/319
4	3041	1983-05-18	200% split break. Average channel power.	-"-	NR-83/320
5	4011	1983-05-20	Guillotine break (155%) with simplified geometry (bypass of RCP1). Average channel power.	-"-	NR-83/321
6	5051	1983-05-26	Guillotine break (200%). Hot channel power.	-"-	NR-83/322
"	5052	1983-05-30	-"-, duplicate test of reproducibility.	Paper plots + electronic. ASCII format, time vs. variable, 48 Hz/channel	NR-83/323
7	3051	1984-05-22	10% split break. Average channel power.	Paper plots only of all quantities in SI units	NR-84/486
8	3061	1984-05-29	100% split break. Average channel power.	Paper plots + electronic. ASCII format, time vs. variable, 48 Hz/channel	NR-84/487
9	3071	1984-06-05	150% split break. Average channel power.	Paper plots only of all quantities in SI units	NR-84/488
10	5061	1984-06-07	Guillotine break (200%). Average channel power.	-"-	NR-84/489

Table 28 - FIX-II Pump Trip Experiments. First Experimental Period. Constant dome pressure 7 Mpa.

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. STUDSVIK
1	2011 2012 2013 2014	1983-08-18 1983-08-18 1983-08-18 1983-08-29	RCP inertia=15 kgm^2 No bypass channel	P_o = 4.26 MW P_o = 4.53 MW P_o = 4.67 MW P_o = 3.69 MW	Paper plots only of all quantities in SI units	NR-83/324
1	2090 2091 2092 2093 2094 2095	1984-06-13 1984-06-13 1984-06-13 1984-06-13 1984-06-13 1984-06-13	Same as above, but with improved pressure control	P_o = 3.90 MW P_o = 4.13 MW P_o = 3.94 MW P_o = 3.70 MW P_o = 4.25 MW P_o = 4.52 MW	-"-	-"-
2	2022 2024 2025 2027 2028 2029 2030 2031 2032	1983-06-03 1983-06-17 1983-06-20 1983-08-17 1983-08-17 1983-08-17 1983-08-17 1983-08-17 1983-08-17	RCP inertia=11.3 kgm^2 No bypass channel	P_o = 3.63 MW P_o = 4.20 MW P_o = 4.32 MW P_o = 3.68 MW P_o = 3.71 MW P_o = 4.12 MW P_o = 4.23 MW P_o = 4.41 MW P_o = 4.44 MW	-"- Only 2032 in electronic. ASCII format, time vs. variable, 48 Hz/channel	-"- -"- -"- NP-87/61
8	2080 2081 2082 2083	1983-08-23 1983-08-23 1983-08-23 1983-08-24	RCP inertia=11.3 kgm^2 13% mass flow to bypass channel	P_o = 4.05 MW P_o = 4.07 MW P_o = 3.93 MW P_o = 3.78 MW	-"-	-"-

Table 29 - FIX-II Pump Trip Experiments. Second Experimental Period. Nominal dome pressure 7 Mpa. Bypass channel disconnected

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)		Data base and format	Test data report No. STUDSVIK
3	2033 2034 2035 2036	1984-04-10 1984-04-10 1984-04-10 1984-04-10	RCP inertia=11.3 kgm^2. Negative pressure ramp, 0.13 MPa	P_o = 3.59 MW P_o = 3.94 MW P_o = 4.13 MW P_o = 4.27 MW	Paper plots only of all quantities in SI units	NR-84/483
4	2042 2043 2044 2045	1984-04-12 1984-04-12 1984-04-12 1984-04-24	RCP inertia=11.3 kgm^2. Positive pressure ramp, 0.13 MPa	P_o = 3.59 MW P_o = 3.84 MW P_o = 4.19 MW P_o = 4.62 MW	-"-	-"-
5	2055 2056 2057 2058 2059	1984-05-02 1984-05-02 1984-05-02 1984-05-02 1984-05-02	RCP inertia=11.3 kgm^2. Positive + negative pressure ramp, 0.13 MPa	P_o = 3.76 MW P_o = 3.88 MW P_o = 4.25 MW P_o = 4.35 MW P_o = 4.26 MW	-"-	-"-
6	2060 2061 2062 2063	1984-06-14 1984-06-14 1984-06-14 1984-06-14	Constant pressure. Faster pump coast down	P_o = 3.68 MW P_o = 3.41 MW P_o = 3.94 MW P_o = 4.58 MW	-"-	-"-
7	2070 2071 2072 2073	1984-06-14 1984-06-14 1984-06-14 1984-06-14	Constant pressure. Still faster pump coast down, and to lower final speed	P_o = 3.42 MW P_o = 3.65 MW P_o = 3.92 MW P_o = 4.59 MW	-"-	-"-

Table 30 - FIX-II Transient Dryout Tests. Imposing of positive pressure and power ramps. After short time with constant power level, scram and RC pump coast down.

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. STUDSVIK
INT.1	6272	1986-02-05	P_o = 4.09 MW, ΔP = +14%	Paper plots only of all quantities in SI units	NP-86/23
INT.2	6284	1985-12-02	P_o = 4.18 MW, ΔP = +20%	-"-	NP-86/1
INT.3	6261	1986-02-05	P_o = 4.19 MW, ΔP = +30%	Paper plots + electronic. ASCII format, time vs. variable, 48 Hz/channel	NP-86/24
INT.4	6292	1985-12-05	P_o = 4.18 MW, ΔP = +32%	Paper plots only of all quantities in SI units	NP-86/3
INT.5	6201	1986-02-19	P_o = 4.39 MW, ΔP = +27%	-"-	NP-86/27
INT.6	6291	1985-12-02	P_o = 4.52 MW, ΔP = +24%	-"-	NP-86/2
EXT.1	6213	1985-12-10	P_o = 3.87 MW, ΔP = +30%	-"-	NP-86/5
EXT.2	6231	1985-12-09	P_o = 3.79 MW, ΔP = +34%	-"-	NP-86/4
EXT.3	6241	1986-02-19	P_o = 4.39 MW, ΔP = +27%	-"-	NP-86/25
EXT.4	6221	1986-02-19	P_o = 4.33 MW, ΔP = +28%	-"-	NP-86/26

Table 31 - **PANDA Test Matrix**

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. PSI
			SBWR PCCs performance tests (Long term post LOCA containment response)		
1	M3	03.10.95	Base case test (Proprietary)	ORACLE data base	ALPHA-601
2	M3A	25.10.95	Repeatability (Proprietary)	""	ALPHA-615
3	M3B	31.10.95	Repeatability (Proprietary)	""	ALPHA-616
4	M2	22.11.95	Asymmetric Case 1 (Proprietary)	""	ALPHA-618
5	M10A	28.11.95	Asymmetric case 2 (proprietary)	""	ALPHA-619
6	M10B	05.12.95	Asymmetric case 3 (proprietary)	""	ALPHA-620
7	M7	14.11.95	PCC start-up (proprietary)	""	ALPHA-617
8	M6/8	12.12.95	System interaction (prop.)	""	ALPHA-621
9	M9	19.12.95	Early start/GDCS phase (proprietary)	""	ALPHA-622
			PCC performance steady-state tests		
10	S1	10.05.95	Pure steam test	ORACLE data base	ALPHA-609
11	S2	"	Steam/air mixture test	""	"
12	S3	"	""	""	"
13	S4	"	""	""	"
14	S5	"	""	""	"
15	S6	"	Pure steam test	""	"

PANDA Test Matrix – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. PSI
16	S10	04.08.95	Repetition of S3	ORACLE data base	ALPHA-609
17	S11	"	Repetition of S5	""	"
18	S12	"	Repetition of S6	""	"
19	S13	"	Pure steam test	""	"
			IPSS Project: Plate condenser tests		
20	PC1	24.11.98	Transient without loss of coolant	ORACLE data base	ALPHA-901
21	PC2	16.03.99	Double-ended MSLB	""	ALPHA-913
22	PC3	18.03.99	Feed-water line break	""	ALPHA-914
			IPSS Project: Building condenser tests		
23	BC1	16.09.97	Transient without loss of coolant	ORACLE data base	ALPHA-832
24	BC2	01.10.97	Small break without core overheat, weak stratification	""	"
25	BC3	21.10.97	Small break, no core overheat, strong stratification	""	"
26	BC4	12.11.97	Small break, core overheat, strong stratification	""	"
27	BC5	18.11.97	Medium break, core overheat, weak stratification	""	"
28	BC6	04.11.97	Large break, no core overheat	""	"

PANDA Test Matrix – cont.ed

Test matrix No.	Exp. I.D.	Date	Type (Characteristics)	Data base and format	Test data report No. PSI
			Isolation condenser steady-state tests		
29	B1 – B3	12.03.97	Pure steam tests	ORACLE data base	ALPHA-732
30	B4 – B12	06.05.97	Steam/air mixture tests	""	"
31	B13 – B15	13.05.97	Steam/helium mixture tests	""	"
			TEPSS Project: ESBWR PCCS performance tests (long-term post-LOCA containment response		
32	P1	09.12.97	Base case	ORACLE data base	ALPHA-716
33	P2	12.01.98	Early start	""	ALPHA-816
34	P3	21.01.98	PCCS start-up	""	ALPHA-819
35	P4	27.01.98	Trapped air in drywell	""	ALPHA-821
36	P5	29.01.98	Symmetric case, 2PCCs	""	ALPHA-823
37	P6	25.02.98	Systems interaction	""	ALPHA-827
38	P7	05.03.98	Severe accident	""	ALPHA-828
39	P8	10.12.97	PCC pool boil down	""	ALPHA-716
			International Standard Problem 42 (ISP-42) on PANDA		
40	ISP-42, Phase A	21/22.04. 98	PCC start-up test	ORACLE data base	ALPHA-835-1, ALPHA-836-1
41	ISP-42, Phase B	"	GDCS discharge	""	"
42	ISP-42, Phase C	"	Operation in case of LOCA	""	"
43	ISP-42, Phase D	"	PCC overload	""	"
44	ISP-42, Phase E	"	Release of trapped air	""	"
45	ISP-42, Phase F	"	Severe accident (He)	""	"

2.4 Overview on Status of Test Data Format and Documentation

Table 7.29 given in the following shows an overview on the status of test data and documentation of the CERTA-TN related experimental programs.

The total number of tests performed is in the order of 1000 which represents a significant contribution from European research organisations to the overall international effort aimed at establishing representative integral system databases for reactor thermal-hydraulic safety analysis. It is important to report that such effort is continuing as some experimental installations are still in operation (e.g. PKL, PANDA, PACTEL, PMK) producing safety relevant test data.

Table 32 - CERTA-TN: Status of Experimental Data

No.	Facility ID	Total No. of tests	No. of tests with data on modern electronic support	No. of tests with data on old electronic support	No. of tests for which only paper support is available	Other	Notes
1	PKL I and PKL II	62	-	-	62	-	
	PKL III A PKL III B PKL III C PKL III D PKL III E	74	30	44	-		
2	BETHSY	82	82			-	All tests results available on hard disk according to the BETHSY internal format
3	SPES 1 SPES 2 SPES 99	10 15 1	- - 1	5 15 -	5 - -	-	
4	LOBI MOD1 LOBI MOD2	70	70	-	-	-	All test data and supporting documentation are in electronic format and are accessible via Internet
5	UPTF 2D/3D UPTF TRAM	237	237	-	-	-	
6	PIPER-ONE	34	5	25	-	4	For 30 of the 34 tests is available a paper documentation. 4 tests are yet to be analyzed.
7	PACTEL	184	22	162	-	-	For 162 of the 184 experiments data is stored on DAT-tapes. For 142 of the 184 experiments a report is available on paper or in pdf-format. For more than half of the experiments the data should be checked before it is ready for storing to the STRESA database.
8	PMK	48	27	21	-	-	
9	FIX-II	93	5	-	88	-	Some of the 88 tests can be found on old ½ inch magnetic tape in CDC, format, but these data are hardly retrievable. Paper plots of all data in SI units exist for all the 93 tests.
10	PANDA	58	58			-	All the test data are stored in electronic form in ORACLE data base

Of the reported tests some are maintained on modern electronic support and as such are easily accessible and/or upgradable. Some test data are available on old electronic support (e.g. magnetic tapes) and as such their access/retrieve depends on availability of adequate read/write computer hardware. In some cases the test data are available only on paper support and as such they need to be scanned and converted to suitable x-y format to be amenable for processing by the user (e.g. comparison of calculated/measured parameters).

With exception of some cases, the test data supporting documentation (e.g. Test Analysis Reports and Experimental Data Reports) are generally available only on paper support.

2.5 Remarks on Databases Current Maintanance Practices

A comprehensive experimental database has been acquired in European integral test facilities during the last three-decades to support thermal-hydraulic safety analysis of water cooled reactors (i.e., PWR, BWR and VVER) and development/assessment of related analytical methodologies. The acquisition of these data has requested a considerable financial commitment from both institutional and industrial reactor safety research organisations which has been estimated in the order of 450 Million EUROs.

To date, some of the experimental programmes have been terminated and several test facilities dismantled; e.g., LOBI, BETHSY, UPTF and FIX-II. Some of the test facilities are still in operation such as PKL, PACTEL, PMK and PANDA; SPES and PIPERONE are in stand-by conditions.

The integral effect test databases, subject matter of this report, are currently maintained in a variety of support media and format. Some support media are not any more serviced by adequate hardware/software and some data are available only on paper format. The extent to which supporting documentation (e.g., test data analysis reports, test facility design drawing, test facility description and information on instrumentation system, etc.) is maintained is some cases questionable.

It is generally recognised that the reported experimental databases represent a unique set of reference information relevant to accident and transient analysis of water cooled reactors. Due to current and even prospected reactor safety research financial constraints that can prohibit revisiting such large scale experimental programmes, it is an obligation of the nuclear community to ensure their preservation and user-friendly access/retrieve capabilities based on modern information technologies.

3 Databases Access and Retrieve Requirements for the Assessment of LWR Safety Codes

3.1 Development of Reactor Safety Systems Codes

Starting with the design and construction of LWRs in the sixties, not only economical but also safety related objectives being of special public interest, have been followed. As a consequence many research projects for the investigation and the prediction of thermal hydraulics in LWRs during off-normal conditions, e.g. LOCAs and transients were initiated.

The prediction of off-normal reactor conditions are generally supported by:

- experimental investigation of system thermal-hydraulic behaviour in scaled test facilities
- safety analysis through the application of qualified versions of computer codes to plant situations.

First generation computer codes like BRUCH-S and RELAP-3 were based on the assumption of thermodynamic equilibrium and equal flow velocity of liquid and steam. With these codes the thermal hydraulic behaviour in the primary circuit during the blow down phase could be described. The influence of components was simulated by simplified models, e.g. time functions. Already in this early period it was realised that codes have to be qualified by the comparison of calculated and experimental results.
The next generation of computer codes was also based on the assumption of thermodynamic equilibrium, but the influence of velocity differences between the liquid and vapour phase was already considered using empirical correlations as in RELAP4 or the dynamic slip model (differential equation for the difference between liquid and vapour momentum) as in RETRAN. With these codes, which had already flexible networks for modelling complex flow systems, BWR plants as well as the primary and secondary side of PWRs could be simulated including all components, e.g. nuclear fuel rods, pumps, pressuriser, accumulators, heat exchangers and balance of plant models.

The development of thermodynamic non-equilibrium codes like CATHARE, DRUFAN, RELAP5, and TRAC was started to overcome the numerical problems during steam condensation caused by pressure waves and cold water injection, which were typical for the equilibrium codes. But in the LOBI Pre-Prediction Exercise (Double ended break in cold leg, accumulator injection in intact loop cold leg) the results calculated with RELAP4 were far better than those obtained with the first versions of the participating non-equilibrium codes, e.g. DRUFAN and TRAC.

After years of code development the situation has changed and the last standard problems, e.g. ISP27 (BETHSY test 9.1b: 2" Cold Leg Break without HPSI and with Delayed Ultimate Procedure; and ISP38 (BETHSY 6.9c: Loss of Heat Removal System during Mid-loop Operation; Pressuriser and S.G.1 Outlet Plenum Manways Open, were dominated by the advanced system codes.

The important advanced system codes, which have been developed in western countries are APROS (Finland), ATHLET (Germany), CATHARE (France), RELAP5 (USA) and TRAC-P (USA), TRAC-BF1 (USA), and TRAC-M (USA) which is presently under development. In

Russia the advanced system code KORSAR is in development. First results have already been presented in the GRS.

With the increasing preference of best estimate code predictions in comparison to conservative code predictions developmental and independent code assessment against a well founded set of tests and real plant transients has become such an important task in the development of advanced system codes, that a “Separate Effects Test Matrix for Thermal-Hydraulic Code Validation”, an “Integral Test Facility Validation Matrix for the Assessment of Thermal-Hydraulic Codes for LWR LOCA and transients” and a "Validation Matrix for the Assessment of Thermal-Hydraulic Codes for VVER LOCA and Transients" have been set up by OECD/NEA-CSNI writing and support group members. The VVER-Matrix contains separate effects as well as integral tests.

Separate effect experiments (SETF) have been performed to study “separable” physical processes similar to those expected in nuclear power plants or to characterise the behaviour of a single component, e.g. main circulation pump or pressuriser. With scaled integral test facilities (ITF) the overall physical processes and the behaviour of PWR or BWR plants during accident conditions have been investigated.

The extent to which the existing reactor safety experimental data bases are preserved and can be eventually accessed and/or recovered is an issue often debated in the nuclear community. In addition to the loss of skilled human resources, a compounding problem is the rapid advancement of computer hardware and software technology which is making several of the storage methods obsolete and as such access to the data practically impaired. Clearly, preservation of the data by itself is not sufficient, if not accompanied by the preservation of supporting information concerning test facility hardware, instrumentation and test results analysis documents.

Although expert groups had repeatedly stressed over the last ten years the urgent need to collect experimental data in the NEA Data Bank, little effective support had been given by the member countries. Out of 1094 separate effects tests (SET) identified in the “Separate Effects Test Matrix for Thermal-Hydraulic Code Validation” up to now only 79 have been stored in the NEA Data Bank Computer Code Validation Matrix (CCVM) and out of 165 integral tests (IT) identified in the “Integral Test Facility Validation Matrix for the Assessment of Thermal-Hydraulic Codes for LWR LOCA and Transients” only 50 have been stored in the CCVM .

In the above outlined general framework, the main purposes of the actual document, which has to be delivered as a result of the work package 2 activities (description of WP2 in /CER 00/), are essentially the following:

- Short description of major system safety codes APROS, ATHLET, CATHARE, RELAP5 and TRAC
- Test facility design and characterisation data for code input deck building up
- Requirements for the access to experimental data for code verification/validation
- Prospected needs in view of evolving software/hardware technologies

The document has been composed on the basis of the information made available by each of the organisations participating in the CERTA-TN program (CERTA.1), the material distributed to the participants of the BETHSY-Standard Problems ISP 27 and ISP 38, the material provided for PKL III post test calculations.

Table 33 - European LWR Integral System Test Experimental Programs

PROGRAMME	DENOMINATION	ORGANISATION	COUNTRY
PKL	PrimärKreisLäufe	Framatome ANP (Siemens/KWU)	Germany
BETHSY	Boucle d'Etudes Thermohydraulique Système	CEA (Grenoble)	France
SPES	Simulatore PWR Esperienze di Sicurezza	SIET - Piacenza	Italy
LOBI	Loop Off-normal Behavior Investigations	JRC - Ispra	EC
UPTF	Upper Plenum Test Facility	Framatome ANP (Siemens/KWU)	Germany
PIPER 1	BWR Simulator	Pisa University	Italy
PACTEL	VVER Simulator	VTT /Lappeenranta University (LTKK)	Finland
PMK	VVER Simulator	KFKI	Hungary
FIX-II	BWR Simulator	Studsvik	Sweden
PANDA	Passive Decay Heat Removal and Depressurization Test Facility	PSI	Switzerland

3.2 Description of Major System Safety Codes

The major system safety codes, which have been applied up to now for plant analyses in the present and future EU member countries, are APROS, ATHLET, CATHARE, RELAP5 and TRAC. Important features of these advanced system codes are:

- Thermal hydraulic models for the simulation of the thermodynamic non-equilibrium effects and phase separation on the basis of the conservation laws for liquid and vapour mass, liquid and vapour energy and liquid and vapour momentum and consideration of the influence of non-condensable gases and boron tracking,
- Heat conduction and transfer models for the simulation of the storage and conduction of heat in the structures and the heat exchange between the structures and the fluid,
- Neutron kinetics models (point kinetics, 1D-kinetics, coupling with 3D-kinetics) for the simulation of heat generation in the fuel rods and the influence of the reactivity on the fission process,
- Models for the operation and control of nuclear reactors and test facilities,
- Models for the simulation of special components, e.g. pumps, steam separators and valves in nuclear reactors or test facilities,
- Flexible network for the modelling and spatial discretisation of complex flow systems and structures,
- Broad basis of developmental and independent assessment against a well founded set of basic tests, separate effects and component tests, integral tests and real plant transients.

Code specific information is given in the short descriptions of APROS, ATHLET, CATHARE, RELAP5 and TRAC.

3.2.1 APROS (Finland)

APROS (Advanced Process Simulation Software), which has been developed in Finland by Technical Research Centre of Finland and Fortum Engineering, is a simulation software product for full-scale modelling and dynamic simulation of processes, such as

- Pulp and paper mills: APROS Pulp & Paper
- Models Nuclear Power plants: APROS Nuclear
- Combustion power plants: APROS Combustion

With each of these, one can model processes based on various gas/liquid/solid flow networks, automation and electrical systems. The APROS simulation environment consists of a simulation engine and a graphical design user interface Grades. The simulation engine contains versatile solvers and model libraries. The Grades provides an easy on-line access for configuring and running the simulation models.

APROS supports the use of dynamic simulation in all different phases during the life span of the process plant, avoiding unnecessary data transfer and reconfiguration of the simulation model, e.g. APROS simulation environment enables the use of engineering simulator as a basis for a training simulator. Once the simulation model has been completed in the design phase it can be re-used with DCS (Distributed Control System) as a checkout and operator training tool with in a cost-effective way.

3.2.2 ATHLET (Germany)

The computer program ATHLET (Analyses of THermal-hydraulics for LEaks and Transients) is being developed in Germany by GRS for the whole spectrum of leaks and transients in PWRs, BWRs and VVERs /TES 98/. The code is also applied for RBMKs.

The code is based on a five-equation system (mixture momentum equation with drift) but has also an option for a full six-equation two-fluid model including non-condensable gases. The reactor coolant system is modelled by a network of one-dimensional components (objects), allowing for cross flow between parallel channels. The time integration method is fully implicit.

Some special features of ATHLET are:

- **Steady-state capability:** A true steady-state, i.e. time independent solution, is calculated to establish the initial conditions.
- **Critical discharge model**: The critical two-phase flow rates for a given geometry are calculated in a pre-processor step as function of the upstream conditions and stored for use during the transient run.
- **Full-range drift-flux model:** A model for the relative velocity between the two phases was developed, based on experimental data for counter-current flow limitation in various geometries. The model comprises options for vertical, horizontal, and inclined channels.
- **Dynamic mixture level tracking:** In a user defined vertical stack of cells, a two phase level with bubble rise below and droplet entrainment above is calculated and dynamically traced across cell boundaries.
- **General Control Simulation Module (GCSM):** A high level simulation language allows via input control to model protection and other balance-of-plant (BOP) systems. Control circuits or even simplified fluid systems are convenient to model this way. GCSM has a general interface for user provided external BOP models.
- **A Integrated Mass and Momentum Balance (IMMB):** This simplified treatment of the mixture momentum equation (one dynamic pressure for a whole loop) is a fast running option especially valuable for long transients. This technique is being extended to permit local flow reversal.

The latest version of the code includes models for subcooled boiling in the core and transport of boron in the cooling system.

The systematic validation of ATHLET is based on a well balanced set of integral and separate effects tests derived from the CSNI code validation matrices; emphasizing however, the German combined ECC injection system which was investigated in the UPTF and PKL facilities.

The development of ATHLET is continued with the aim to improve realism and accuracy of the models based on the feedback from validation and application, enhance calculating speed, diminish the user influence on the results, complete the validation, and quantify the remaining uncertainties.

3.2.3 CATHARE (France)

The CATHARE thermalhydraulic code has been developed jointly by CEA, EDF (the French Utility) and FRAMATOME (the French Vendor) for safety analysis. The purpose of the code is to perform best estimate calculations of thermalhydraulic transients in Pressurized Water Reactors for postulated accidents or other incidents.

Main characteristics of the CATHARE code are:

- The code is able to model any kind of experimental facility or PWR (western types and VVER types) and is used for some BWR studies.

- **Code structure:** The code Cathare is ***modular***, several basic modules may be assembled to modelize the primary and the secondary circuits of any Pressurized Water Reactor or of any analytical test rig – separated effects – or integral test rig – system effects -. 0D, 1D and 3D modules are available. All of those modules can be connected to walls, exchangers and fuel rods – radial conduction, thermomecha-nics -. A 2D conduction calculation is generally done to cope with the quenching of a hot reactor core during a reflooding process. Other submodules are used to compute point kinetic neutronics, pumps speeds, accumulators, sources, sinks.... Such a code structure allows to model a large range of Nuclear Power Plants circuits and accidents scenarii.

- **Physical models:** All the previous modules use the ***2-Fluid Model*** to transport steam-water flows mixed to four noncondensable gases. Thermal and mechanical nonequilibria are described through mass, energy and momentum balance equations writen for each phase. All kinds of two-phase flow patterns – stratified, bubbly, slug, churn, annular, dispersed – may be treated. Co-current and counter-current flows are computed with the prediction of the Counter-Current Flow Limitation. Heat transfers with wall structures or fuel rods are calculated taking into account all possible heat transfer processes such as natural and forced convection with liquid or gas phases, subcooled to saturated nucleate boiling, critical heat flux, film boiling and film condensation. The interfacial heat and mass transfers describe stable mechanisms like condensation due to subcooled liquid and vaporization due to superheated steam. Metastable mechanisms can also be represented : flashing of superheated liquid and condensation of subcooled steam. The effects of noncondensable gases such as hydrogen, nitrogen, air are taken into account in the modelling of the previously described phenomena.

  The ***range of physical parameters*** in Cathare is rather large and devoted to the study of many Nuclear Power Plants accidents : pressure from 0.1 to 16 MPa, liquid temperature from 20°C to 350°C, gas temperature from 20°C to 1800°C, fluid velocities up to supersonic conditions, duct hydraulic diameters from 0.01 to 0.75m. An important and rather extensive experimental program has been carried out to support the validation of the code.

- **CATHARE numerics:** All the CATHARE modules – except the 3D which is semi-implicit in time - use a ***fully implicit time discretization***. Interphase exchanges, pressure propagation and advective terms are thus totally implicitely evaluated. This numerical choice has been done since the beginning of Cathare development in 1979 and has been confirmed by a market research stage before developing the more recent versions of Cathare. The purpose being of course to reach the largest time step possible without any CFL time step limitation, especially for long duration transients. Concerning space nodalization, 1D and 3D modules use ***Finite Volumes Dicretization*** methods for mass and energy equations and ***Finite Differences Dicretization*** methods for momentum balance equations. The meshes are staggered according to the ***ICE method*** : scalar points are bounded by vector points, mass and energy balances are assessed on scalar points while momentum balances are assessed on vector points. Finally, at each time step and for every type of Cathare module, one has to find the solution of a set of non linear equations : a full Newton iterative method is then used

- **CATHARE methodology of development and assessment:** The Cathare software development process distinguishes *code Versions* and ***code Revisions***. A **code Version** is a set of software modules able to represent reactor components, each one with a numerical scheme associated to a solution procedure. A new Version can extend the code capabilities, can add new modules, can make a change in the code architecture or can optimize the solution procedure. A code Revision is a given package of physical closure relationships : thus, a new Revision enables the code to compute new physical situations like, for instance, a new flow pattern zone or a new range of physical parameters.

The constitutive relation-ships are developed and assessed following a general methodology:

Step A: Analytical experiments, including separate effect tests and component tests, are performed and analyzed. Separate effect tests investigate a physical process such as the interfacial friction, the wall heat transfer,...Component tests investigate physical processes which are specific to a reactor component, such as the phase separation in a Tee junction.
Step B: Development of a complete ***Revision*** of constitutive laws from an extensive experimental support program.
Step C: ***Qualification*** calculations of the analytical tests in order to validate each closure relationship on a large separate effect test matrix.
Step D : *Verification* calculations of system tests or integral tests, including BETHSY tests, in order to validate the general consistency of the Revision.
Step E: Delivery of the code Version + Revision fully assessed (qualified and verified) and documented (description documents and assessment reports).

When predictions are not correct or not accurate enough in the qualification (step C), it will be correc-ted in steps A and B of the future Revision. When predictions are not correct or not accurate enough in the verification calculations (step D), no correction of a closure law will be applied without coming back to analytical tests (step A). New analytical tests may be defined if a physical process was not treated before.

In this program, 1000 separate effect tests will be calculated for the qualification phase and 25 integral test will be used for the verification phase.

- **The user's effect:** All system codes for nuclear thermalhydraulics are subject to the so called user's effect: Different users may obtain different results for the same problem. In order to minimize this undesirable effect, the code is fully portable on all machines, so that a unique code Version is released to all the users and no code options for physical models are proposed to the user. Only the CCFL in complex geometries requires user's flooding correlations.

CATHARE code documentation: The Cathare documentation comprises different types of documents:

Code Use and Code Implementation (User's Manual, User Guidelines, Dictionary of operators and directives, Implementation manual)
Descriptive documents (CATHARE general description, Description of each module & submodule, Description of constitutive laws)
Descriptive documents (CATHARE general description, Description of each module & submodule, Description of constitutive laws)

All CATHARE users participate to the CATHARE Users Club (CUC) and report their work to CUC meetings. The minutes of these meetings are also parts of the CATHARE documentation.

All the documents refer to a code Version and Revision. The User Guidelines contain many advises for writing an input deck and running calculations. It is the result of the experience of the code. These guidelines contain in particular :

- advises concerning the choice of CATHARE modules for modeling reactor components
- advises concerning the choice of mesh size and maximum time step

- why, when and how to use the CCFL option model
- indication of physical processes which are not yet well modeled by any module
- warnings about most the frequent users errors.

- **Application of Cathare to plant simulators:** The use of CATHARE based simulator software has been effective since the middle of the 80's. At this time a simplified version of CATHARE, named CATHARE-Simu, was developed and implemented as a kernel module of the SIPA simulator.

  The use of CATHARE based simulator software has been effective since the middle of the 80's. At this time a simplified version of CATHARE, named CATHARE-Simu, was developed and implemented as a kernel module of the SIPA simulator. (see Fig. 2-3-1)

- **Coupling of CATHARE with other codes:** For several applications, it is necessary to use the code not only in a standalone mode, but also in cooperation with other system codes (i.e. neutronic, fuel behavior, CSD, containment, ...). Coupling of CATHARE with the severe accident code TOLBIAC to calculate the external cooling of the pressure vessel when the corium is falling down to the lower plenum and with ICARE2 code to analyze core degradation and fission product release have been performed and the coupling with three dimensional neutronics codes such as CRONOS and COCCINNELLE are under development.

- **CATHARE status:** At present time, the Version C2V1.3L, an industrial version, contains the Revision 5 with some improvements in Reflooding Modelling. The last Version C2V1.5a (released at the end of the millennium) has a completely new code architecture, a 3D module for pressure vessel or containment nodalizations, a Discrete Adjoint Sentivity method for code physical uncertainties evaluations and a new package of physical models, the Revision 6.

3.2.4 RELAP5 (USA)

The RELAP5 code has been developed for best-estimate transient simulation of light water reactor coolant systems during postulated accidents. The RELAP5/MOD3 is a system transient analysis code that can be used for simulation of a wide variety of system thermal-hydraulic transients of interest in light water reactor (LWR) safety. The primary system, feedwater train, system controls, and core neutronics can be simulated. The code models have been designed to permit simulation of postulated accidents ranging from large break loss-of-coolant accidents to accidents involving the plant controls and fuel system. RELAP5 is a highly generic code that, in addition to calculating the behaviour of a reactor coolant system during a transient, can also be used for simulation of a wide variety of hydraulic and thermal transients in both nuclear and non-nuclear systems involving mixtures of steam, water, non-condensable and solute.

The RELAP5/MOD3 hydrodynamic model is a one-dimensional, transient, two-fluid model for flow of a two-phase steam-water mixture that can contain a non-condensable component in the steam phase and/or a non-volatile component in the liquid phase.

The two-fluid equations of motion that are used as the basis for the RELAP5/MOD3 consist of two phasic continuity equations, two phasic momentum equations, and two phasic energy equations. The equations are formulated in terms of volume and time-averaged parameters of the flow. The phenomena that depend upon transverse gradients, such as friction and heat transfer, are formulated in terms of the bulk properties using empirical transfer coefficient formulations. The system model is solved numerically using a semi-implicit finite-difference technique. The user can select an option for solving the system model using a nearly implicit finite difference technique, which allows violation of the material Courant limit. This option is suitable for steady-state calculations and for slowly varying, quasi-steady transient calculations.

The semi-implicit numerical solution scheme uses a direct sparse matrix solution technique for time step advancement. The method has a material Courant time step stability limit. However, this limit is implemented in such a way that single-node Courant violations are permitted without adverse stability effects. Thus, single small nodes embedded in a series of larger nodes will not adversely affect the time step and computing cost. Nearly implicit numerical solution scheme also uses a direct sparse matrix solution technique for time step advancement.

The constitutive relations include models for defining flow regimes and flow regime related models for interphase drag, wall friction, heat transfer, interphase heat and mass transfer and reflood heat transfer. The constitutive relations include flow regime effects for which simplified mapping techniques have been developed to control the used constitutive correlations. Three flow regime maps are utilised. They are vertical and horizontal maps for flow in pipes, and a high mixing map for flow in pumps.

A boiling curve is used in RELAP5 to govern the selection of heat transfer correlations. In particular, the heat transfer regimes modelled are classified a pre-critical heat flux (pre-CHF), CHF, and post-CHF regimes. Condensation heat transfer is modelled and the effects of non-condensable gases are included. Heat structures provided in the code permit calculations of the heat transferred across solid boundaries of hydrodynamic volumes. Heat structures are assumed to be represented by one-dimensional heat conduction in rectangular, cylindrical, or spherical geometry. Finite differences are used to advance the heat conduction solutions.

3.2.5 TRAC-BF1 (USA)

The TRAC-BWR series of codes have been developed to provide a capability for boiling water reactor (BWR) analysis. It can be used for simulation of a wide variety of BWR system transient s of interest in LWR safety. The code is capable of simulating the reactor system, including the vessel, its internal components, the external circulation systems, emergency cooling systems, reactor control systems, balance of plant components such as turbines, condensers, heaters, etc. and the reactor containment.

The TRAC-BF1 hydrodynamics model is based on a six-equation description of two-phase flow in three-dimensional and one-dimensional components. It includes additional conservation equations for flow of non-condensable gases mixed with the vapour, and for boron transport with the liquid phase. The two-fluid equations consist of a mixture mass balance and a vapor mass balance, momentum equations are in effect reduced to be represented in terms of velocities.

The closure of this system of equations is achieved through specification of the thermodynamic equations of state for each phase, the interfacial shear coefficient, the interfacial heat transfer rates for liquid and vapour, the interfacial mass transfer rate, and the wall shear coefficients.

The TRAC numerical solution scheme employs a semi-implicit solution of the finite difference form of the field equations. The numerical scheme used also allows to use multiple pipe connections to a single-vessel hydrodynamic cell and to solve the two-fluid hydrodynamics in one-dimensional flow components. At least four computational passes are made through each component. A pre-pass is made to update certain explicit information that must be available before performing the hydrodynamic calculation (e.g., heat transfer coefficients). The next two or more passes call the basic hydrodynamic routines until a solution is obtained within the convergence criterion. The final pass updates the conduction solution.

The Courant-limit violating solution scheme (fast numerics) introduced in TRAC-BF1 is applied to all one-dimensional components and replaces the semi-implicit solution for those components. This fast numerics is a hybrid technique based on a combination of the stability-enhancing two-step method developed at LANL and the predictor-corrector method developed at GE. It employs the GE method of stabilising the momentum and the LANL method of conserving mass and energy, when violating Courant limit.

Three fundamental heat transfer mechanisms are modelled by the TRAC code in all components. They include the interfacial heat transfer between the vapour and liquid phase, conduction within structural components, and heat transfer between the structures and the fluid. The thermal history of the structural material s is obtained from a solution of the heat conduction equation. Transient heat conduction and temperature distribution calculations in TRAC-BWR are performed with a time-dependent one-dimensional equation that can be applied to regular geometries such as slab, cylinder or sphere.

The energy exchange between the structures and the fluid is modelled using Newton's law of cooling. The coupling algorithm is semi-implicit. For each time step, the fluid dynamics equations are solved based on previous values for the wall heat transfer coefficient and surface wall temperatures. The wall-to-fluid heat transfer coefficients are obtained from a generalized boiling curve containing four principal regimes: single-phase liquid forced convection, nucleate, boiling, transition boiling, and film boiling. In addition, convection to single-phase vapour and condensation are included.

An important aspect of heat transfer in BWR fuel bundles during a LOCA transient is thermal radiation from the fuel rods to the coolant and the channel walls. Calculation of radiation heat transfer was one of the first important features that was included in TRAC-BWR series of codes.

3.2.6 TRAC-M (USA)

The U.S.NRC is currently consolidating the capabilities of its four thermal-hydraulic codes (which use different constitutive packages and numerical methods and have similar but not identical capabilities due to their different application areas: TRAC-P, TRAC-B, RAMONA, RELAP5) into a single code. The goal of the effort is to recover the functionality of the current suite of codes while reducing the maintenance and development burden. Consolidation consists of three major stages.

The first is creation of a modern architecture under which desired features can be implemented and maintained with minimal effort. The second is installation of the general modeling capabilities (mesh topology, system components, and physical processes) of the four predecessor codes. The third is assessment during which the best model or correlation from the predecessor codes will be installed, so that the consolidated code will generate results as good as the predecessor codes for the targeted applications.

A modernized and modularized TRAC-PF1/Mod2 version 5.4, now called TRAC-M, serves as the basis for the consolidation. The architecture has been reformed and the language migrated to FORTRAN90 to produce a more modular, readable, extendable and developer-friendly code. The general use of F90 modules helps to protect data, compartmentalize functionality and data, and ensures data type consistency.

As the user community requests additional code capabilities in response to increases in available computing power, the danger exists to complicate the code and its architecture, hindering further development and maintenance. To prevent this, USNRC has adopted the design strategy of coupling the code across a well-defined interface. This strategy was utilized in providing the code with a 3-D kinetics capability.

A neutronics package has been coupled to TRAC-M using PVM to provide a one-dimensional (1-D) and three-dimensional (3-D) kinetics model without having to add this functionality to the TRAC-M code itself. This allows the ability to improve the neutronics model or hydraulic model in TRAC-M independently. To allow this logic to be extended to other functional models and to make its implementation consistent in each case, an exterior communication interface is under development.

The exterior communication interface will also facilitate coupling to other codes, such as CFD codes, sub-channel analysis codes or more detailed containment codes.

BWR components were incorporated into TRAC-M using the modeling philosophy of TRAC-B. In TRAC-B, these components were built based on generic 1-D components, such as pipes and tees. Special terms were added to the generic equations, if a BWR component were being modeled. Since TRAC-M already models generic components, only the BWR component specific terms were migrated to TRAC-M.

Therefore, the consolidated code is not a super-set of TRAC-B and TRAC-M. TRAC-M has the ability to read a TRAC-B input deck and these decks are being run as a means of identifying constitutive models that must be used by the BWR components to produce results that are consistent with TRAC-B and data. Throughout the consolidation effort, improvements have been made to the code. These include: a semi-implicit numerics scheme to be used as an alternative to SETS (stability-enhancing two-step method) in order to reduce numerical diffusion; an exterior communication interface, which facilitates the coupling of TRAC-M to processes running outside of the TRAC-M code, such as a simplified accumulator model.

Effort has also been spent in modifying TRAC-M to facilitate the conversion of RELAP5 input decks. This functionality will be provided by the graphical user interface (SNAP) currently under development for both TRAC-M and RELAP5. A demo version of SNAP, which is not fully operational, is already available. Once the consolidation of the BWR applications (TRAC-B and RAMONA consolidation) is completed, and the code has been fully assessed, USNRC will then determine whether to initiate the consolidation of RELAP5.

This work will mainly involve assessing the codes against each other and data and modifying TRAC-M constitutive models to allow TRAC-M to simulate phenomena associated with RELAP5 applications, while preserving its simulation fidelity with respect to those of the other codes. Completion of consolidation process is expected to be in 2003. However, USNRC will continue to maintain RELAP5 (since regulatory side of NRC is using mostly RELAP5) and make user-requested improvements. Throughout this process, USNRC will ensure that user needs are accommodated and will provide a transition period during which the codes are maintained until the user community has moved (with full confidence) to the consolidated code. The schedule is not yet determined, but could be next 4-5 years.

Presently, the next stage in the consolidation process is developmental assessment. A developmental assessment matrix is being developed based on code application. Therefore, the TRAC-B, RAMONA and TRAC-P functionality will be tested. The matrix is developed based on existing PIRTs, CSNI test matrices and each of the codes' developmental assessment matrices. These tests will be run to ensure that the consolidated code simulation fidelity is acceptable for all applications. There are also initiatives to improve some of the physical models in the consolidated code, based on new experimental work. These are:

- Interfacial area transport will replace static flow regime maps
- Sub-cooled boiling at low pressure
- Phase separation at Tees
- Rod bundle heat transfer program (Reflood)

3.2.7 Selected nodalization schemes

In figs. 2.7-1 to 2.7-22 scetches of nodalization schemes are represented, which have been applied for post test calculations of BETHSY, PACTEL, PANDA, PIPER ONE, PMK, LOBI MOD2, PKL III, SPES, UPTF and UPTF TRAM experiments with APROS, ATHLET, CATHARE, RELAP5 and TRAC code versions.

3.3 Test Facility Data Required for Code Input Deck Building up

In the assessment and validation of advanced computer codes and the training of code users building up input decks for the prediction of separate effects tests and integral tests is an important task, which requires extensive information about the test facility and the selected test. This comprehends description of the test facility, information about arrangement, geometry and material of the components, data of plant and special component characteristics, initial and boundary conditions and location of measuring instruments including the physical quantities to be determined.

3.3.1 General description of the test facility

To get an idea and an understanding of the test facility and of the tests a general description of the test facility including the plant history, the purpose and background of the tests, scaling principles and modelling aspects, similarities and differences between the test facility and the reference plant.
For planning and preparation of the plant model in the input deck information about the complete configuration of the test facility with its components, pipes and connected system is required. This must be supported by overview pictures and schematic drawings. The number of similar or identical components (e.g. steam generators, accumulators valves and main coolant pumps) and sub-components (e.g. heater rods, steam generator tubes) must be pointed out. The components in the test facility, which are multiple components of separate components in the reference plant (e.g. double loop instead of two separate loops), have to be identified. Also knowledge about the task, operation and behaviour of the components in the test facility and the performance of special components like coolers and pumps has to be provided.

The test specific configuration of the test facility has to be outlined in the test report, because in the different experiments not all components and sub-systems have been activated or connected to the main system and must not be considered in the input deck.

3.3.2 Spatial arrangement, geometry and material of the components and pipes

Drawings showing the overall facility layout, the spatial arrangement with exact position of the components and the detailed geometry of all the components and pipe connections must be provided, preferably such drawings which are made to scale. The dimensions, e.g. of diameters, lengths, heights, gap widths, wall thickness, number of components and sub-components with identical geometry, should be included in these drawings. Isometric drawings are also helpful. It is desirable that quantities of obvious interest to code input such as volumes, flow areas, wall thickness and lengths are additionally presented in form of diagrams or tables. In several cases the experimentalist has measured the content of the components of the test facility in liters. With this method the volume of components with complicated geometry has been determined.

The materials utilised for the components of the test facility, e.g. structures of the flow channels, vessels and heater rods, filling materials and the outside insulation have to be specified by the experimentalist. The material properties, e.g. density, heat conduction and heat capacity should also be provided, above all the properties of special materials, which are not well known or new.

3.3.3 Characteristics of the test facility and of special components

The knowledge of the overall and local heat losses, the flow distribution and the pressure losses in the flow channels of the test facility is of high importance for building up an input deck. Therefore the results of the corresponding characterisation tests should be provided.

The characteristics of special components like the homologous curves of the main coolant pumps, the separation efficiency of steam-water separators, pressure loss in valves during opening and closing and flow characteristics of orifices must also be delivered. In some cases, descriptions, which include such information, have been prepared by the manufacturers.

Knowledge about form loss coefficients of special geometrical configurations, e.g. core entrance and exit geometry or upper head bypass, should be made available by the experimentalist.

3.3.4 Initial and boundary conditions

All initial and boundary conditions, which are influencing the course of the experiment, have to be made available.

Important quantities among the initial conditions are, for instance the temperature, pressure and mass flow distribution, magnitude of heat sources and heat sinks.

Examples for boundary conditions, which are bearing upon the conditions during the test, are heat production in the fuel rod simulators or actions of the controllers for opening and closing of discharge valves or starting ECCS injection. The design and the mode of operation of the controllers or their approximation have to be described. The sequence and chronology of test operations and controls must be described for the actually achieved actions. The degree to which the desired boundary conditions were achieved or not achieved should be discussed.

For some types of boundary conditions such as heat sources detailed information about the design/configuration of the relevant portion of the facility (e.g., fuel rod simulators) has to be included.

3.3.5 Location of measuring instruments

In view of the comparison of the code prediction and the experimental data, e.g. the location, the geometry and the spatial measuring range of the measuring instruments in the flow channels and structures, has to be considered in the preparation of the nodalization or discretisation scheme of the flow channels and structures. The physical quantities, which are determined by means of the measurements, e.g. pressures, temperatures, mass flow rates, must be given.

Therefore detailed drawings are necessary, which contain the assigned sensor designation, type of physical variable measured and the precise location in the facility with location coordinates. The spatial measuring range, e.g. scattering angle the beam of a γ-densitometer, should be described. It must be completed by a detailed description and drawings of how and where the measuring instruments are installed or mounted in the facility.

3.4 Access and Retrieve Requirements of Experimental Data for Code Assessment

Code assessment requires the prediction of selected experiments and the comparison to the corresponding qualified experimental data. In the framework of this work the access and retrieve of the experimental data is an important task.

3.4.1 Specifications for qualified experimental data

The specification for qualified experimental data include a description of the measuring instrumentation, a description of the acquisition, processing and archiving of the experimental data, the evaluation of the data and the quantification of uncertainties and the documentation in an experimental data or test report.

- **Description of the measuring instrumentation:**

  A list of all instrumentation should be provided that includes the assigned sensor designation, type of physical variable measured and its dimension, type of sensor, range or limit of measurement, general location in the facility and precise location coordinates. The measurement uncertainties must be quantified for each sensor. For each sensor, information should be provided identifying the manufacturer, design or configuration and working principle of the instrument if it is not a common type of sensor, as well as a detailed description and drawings of how it is installed or mounted in the facility (see also sect. 3.5).

- **Description of the data acquisition system:**

  The description should include data acquisition hardware and the sampling rate for the various sets of channels. A list of all data channels should be provided identifying the assigned data channel as well as the input sensor/signal or calculated quantity derived from two or more sensor measurements. Uncertainties associated with the data acquisition system should be quantified.

- **Processing and archiving of experimental data:**

  The procedure used to convert raw data into the presented test results must be described. Information on how sensor output voltages were converted into physical variables must be provided. Any data filtering, smoothing, fitting, etc. carried out must be discussed in detail. The procedures employed should not introduce significant uncertainties into the results or cause the results to be misleading. The experimental data converted from raw data to the physical variables have to be maintained and archived on electronic media. Also raw data should be permanently maintained such a way that they remain available for a possible future reprocessing. Object of consideration is whether the electronic medium used for data archiving or the format of the data is likely to become obsolete the way that data will cease to be accessible in a practical sense.

- **Evaluation of data:**

  The presentation and discussion of experimental results must include documentation of how the data were evaluated to arrive at those results. This involves not only conversion of sensor output voltages to physical variables but also documentation of the basis and application of any models used to infer the values of variables that could not be directly measured or were not directly measured. Ambiguities in the results that arise due to the lack of additional instrumentation not incorporated in the test or significant uncertainties in measurement and evaluation, should be identified. The experimentalist has to examine the physical consistency of the data and if the experimental results are influenced e.g. by the failure of some measuring instruments or signal transfer further unexpected incidents like leakage of a sealing or blockage of a valve. Comparisons to the results of similar experiments should be performed.

- **Quantification of uncertainties:**

  Following the test, a quantification of the overall uncertainty in each result presented should be performed and documented in detail. The evaluation should not be limited to more sensor and data acquisition statistical uncertainties but also include uncertainties associated with modeling of the response of the sensor in its mounting environment as well as uncertainties associated with modeling relationships between any inferred variables and those subject to direct measurement. The reproducibility of the experimental results should be mentioned.

Experimental data report:

The experimental results should be described and discussed in an experimental data or test report including the preceding points. The report must also contain the time plots of the measured physical quantities and tables with the initial and boundary conditions.

3.4.2 Access and retrieve of experimental data

In the framework of code assessment and evaluation the code predictions have to be compared to the experimental results. For the assessment activities both the test reports, which should mediate an understanding and knowledge of the test results, and the experimental data in electronic form have to be provided. The access and retrieve of the experimental data archived on electronic media has always been a decisive problem in this work and the requirements may be concluded from the hitherto practice and experience.

- **Transfer and retrieve of experimental data archived on electronic media:**

  In the past electronic data have mainly been archived and transferred on magnetic tapes (format: label, no-label) on reels, then on cartridges (e.g. TK50, DC 8 mm, DDS 4 mm). In several cases the experimentalists were not able to retrieve their experimental data on old tapes, because of aging problems, missing old tape machines or change of operating systems. Herewith these data cannot be retrieved and are lost for code assessment. In the near future also old cartridge readers are coming out of use.

  Presently small amounts of new experimental data are archived on diskettes and large amounts on compact disks (CDs). Some institutions have started to copy old experimental data from tapes to CDs. It is supposed that CDs have a long life time and that CD-readers are not obsolete so fast. Thus future retrieve of the data seems to be guaranteed. Archiving of data on CDs is therefore recommended.

  In some cases experimental data and also the corresponding test reports are archived in a data bank e.g. STRESA on a server, from which both can be copied via internet. As the data bank on a server is permanently maintained, access and retrieve of the data is supposed to be guaranteed for a long time period. For the data transfer with an acceptable transmission time (< 1 min) the size of data files should be <10 Mb. The transmission of data files with a size of several Gb could last up to one day with many interruptions. In spite of these problems transmission of experimental data via internet is already a fast and reliable method.

- **Information necessary to transform and to use the experimental data transmitted on electronic media:**

  Beside transmission of the experimental data on electronic media the experimentalist has to provide information, which the user needs to transform the data into such a structure and format that can be processed by the user specific plot program. In particular the following information is required:

- Type of the data format: e.g. binary, ascii (size binary/ascii ≈ 1/4), excel,
- Organisation and structure of the data,
- Assignment of electronic data vectors/channels to names of the variables or measuring positions,
- Physical dimensions of the variables in the data vectors.

This information must be provided in the test report or in a log-file (ascii-format) on the electronic medium.

- **Administration and long time archiving of experimental data on electronic media:**

  After a test program has been finished the experimental raw data and the converted data should be archived, administrated and maintained by a central administration group, which is independent of project funding. But only these test data should be archived in a central data bank, which have been evaluated and for which test reports have been written. It is very difficult to access and retrieve experimental data on electronic media, if no descriptions and test reports exist and the experimentalists have already changed working area.

3.4.3 Prospected Needs in View of Evolving Software/Hardware Technologies

Prospected needs in view of evolving software/hardware technologies are oriented at the progress of the server hardware, the software and the internet capabilities. Organisational aspects have also to be included. That these needs can be fulfilled has already been demonstrated in small scale with the STRESA-data bank for LOBI-data.

- **Evolving server hardware technology:**

  In the framework of evolving server hardware technology one may expect that calculating velocity of the servers and storage capacity of the hard-disks will increase more and more, but the costs for server hardware and service will decrease. This should promote, that in the future all experimental data obtained in the different institutions could be archived in data banks on servers, so that on-line operation is possible. This allows fast and permanent maintenance of the data in case of changing technology and fast and uncomplicated use of the data for code assessment or answering questions e.g. of authorities supervising nuclear reactors. The converted experimental data should be recorded in ascii-format and SI- or engineering units to simplify the exchange of data with other institutions. At least tools should be available to perform an on-line transformation of a binary-format into ascii-format and from the original units into SI- or engineering units.

  With growing storage capacity not only the test data but also the test reports and facility data e.g. descriptions and drawings should be stored on the servers, the drawings in a pdf image file format ensuring sufficient resolution and the text-files in pdf-format preferably in text format to facilitate search. Text storage in image format obtained from scanning could also be applied, if sufficient resolution is ensured.

- **Software tools for representing the experimental data:**

  The user of the experimental data needs software tools which ensure an effective representation of the data, e.g. local or time plots of variables, selection and storage of variables, time and local windows, reduction of points in a time period and tools with uncomplicated and self explaining handling. The plotting software of the STRESA-data bank can already fulfil such needs.

- **Software tools for effective comparison of measured and calculated data:**

  One time-consuming task in code assessment is to create the comparison plots between measured and calculated data. If there is a large number of measured parameters it requires some skill to make the correspondence between the appropriate set of measured/calculated parameters. The usual way of doing that today is by retrieving the selected parameter from the plot file of the given systems code, select the nearest measured value and create a comparison plot. This procedure could be simplified, if the plotting software existing already in e.g. the CERTA data bank could be used to represent not only measured, but also the calculated data. To that purpose CERTA should be extended by a routine that is able to read the plot files of major thermal-hydraulic systems codes. Creation of comparison plots then could be done with present capabilities of CERTA. This would also facilitate inter-comparison of different code results.

- **Internet for transmission of data and interconnection of institutions:**

  One may expect that by the evolving internet technology the capacity of the internet will be extended. This means that transmission times of data files will be shortened, the size of data files can be increased and interruptions will be reduced. The extending internet capacity will allow the transmission of data files with very large size e.g. UPTF-data files (size: some Gb) and the interconnection of many institutions not only in batch but also in on-line operation. As a result the use of experimental data can be intensified and the assessment level of the EU-codes raised. This interconnection should not be limited to the CERTA network members but extended to other institutions e.g. of OECD members.

- **Organisational aspects:**

  With the evolving technology and the extension of the experimental data network questions of organisational aspects have to be considered, e.g. adopting of new software/hardware tools and standardising of tools in the data network to force up the effectiveness of the data network, protecting the data network against disturbances or training of new participants. To manage such aspects the data network should administrated under the leadership of an European institution.

3.5 Remarks on Data Requirements for the Assessment of LWR Safety Codes

A considerable amount of resources has been devoted over the past three decades to the acquisition of experimental databases a) for the identification/verification of basic thermal-hydraulic phenomena governing the evolution of accidents and transients in water cooled reactors and b) for the provision of relevant test cases to assess the predictive capabilities of system codes used in reactor safety evaluation.

There is a general consensus of opinions that there is a persisting requirement to access integral system experimental databases in order to support the application of the current generation of safety codes as well as to sustain the refinement of models and of numerical schemes in advanced versions or even in new generations of codes. In addition to dedicated safety analysis application, it is also retained that experimental databases constitute a significant reference to support educational activities.

Referring to the application of the experimental data to code development and assessment it emerges that particular attention has to be placed on:

- Preservation of the data using modern information technologies which can be easily accessed and retrieved as well as upgraded to follow the development and eventual introduction of new hardware and software technologies
- Maintenance of reference information for the interpretation of the experimental results which may include Experimental Data Reports and Test Analysis Reports
- Provision of reference information concerning test facility design and operational characteristics which are needed for code input deck building up.

It is of particular relevance a correct documentation and availability of test facility characterisation test data as well as provision of operational data concerning major thermal hydraulic components. Within this context the following is emphasized:

- Test facility lay-out and geometrical configuration
- Material properties
- System and components pressure losses
- Amount and distribution of heat losses and heat gains
- Alignment and horizantality of pipework
- By-pass flow paths and pipe-work or components dead-ends
- Quantification and location of eventual system leaks
- Main Coolant Pump 1 and 2 phase hydraulic behaviour
- Characteristics of safety valves
- High Pressure and Low Pressure Injection System characteristics
- Accumulator Injection System behaviour
- Control and data acquisition system characteristics
- Instrumentation location, characteristics and eventual error bands.

Taking into account that above is not to be considered exhaustive, it is important to point out that preservation of measured data needs to be complemented by preservation of all supporting information in order to minimize the influence of uncertainties in test facility geometrical/operational characteristics on code input deck building up and on the related code predictive capabilities.

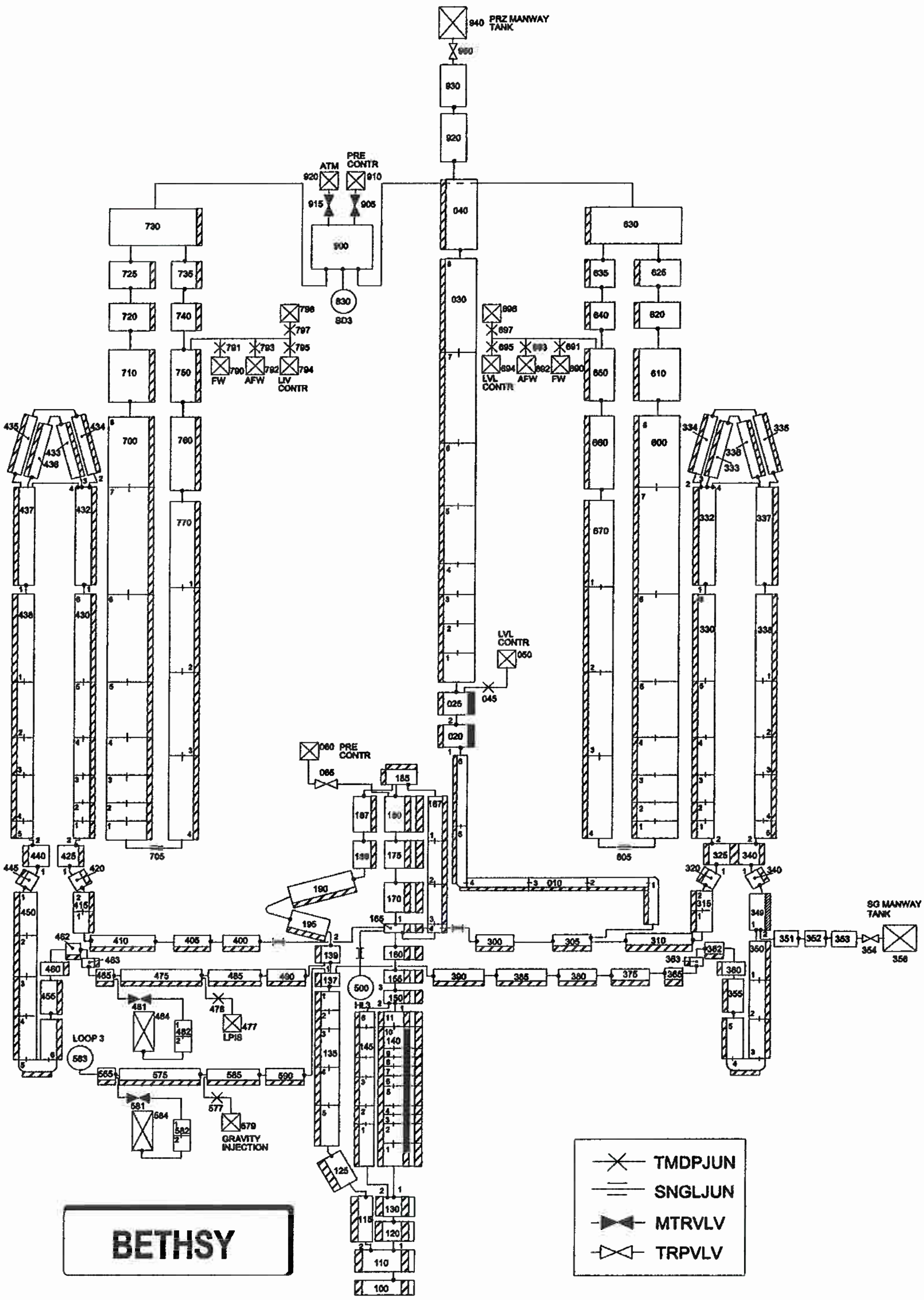


Fig. 12 : Sketch of the BETHSY nodalization for Relap5 code, adopted in the analysis of the ISP 38

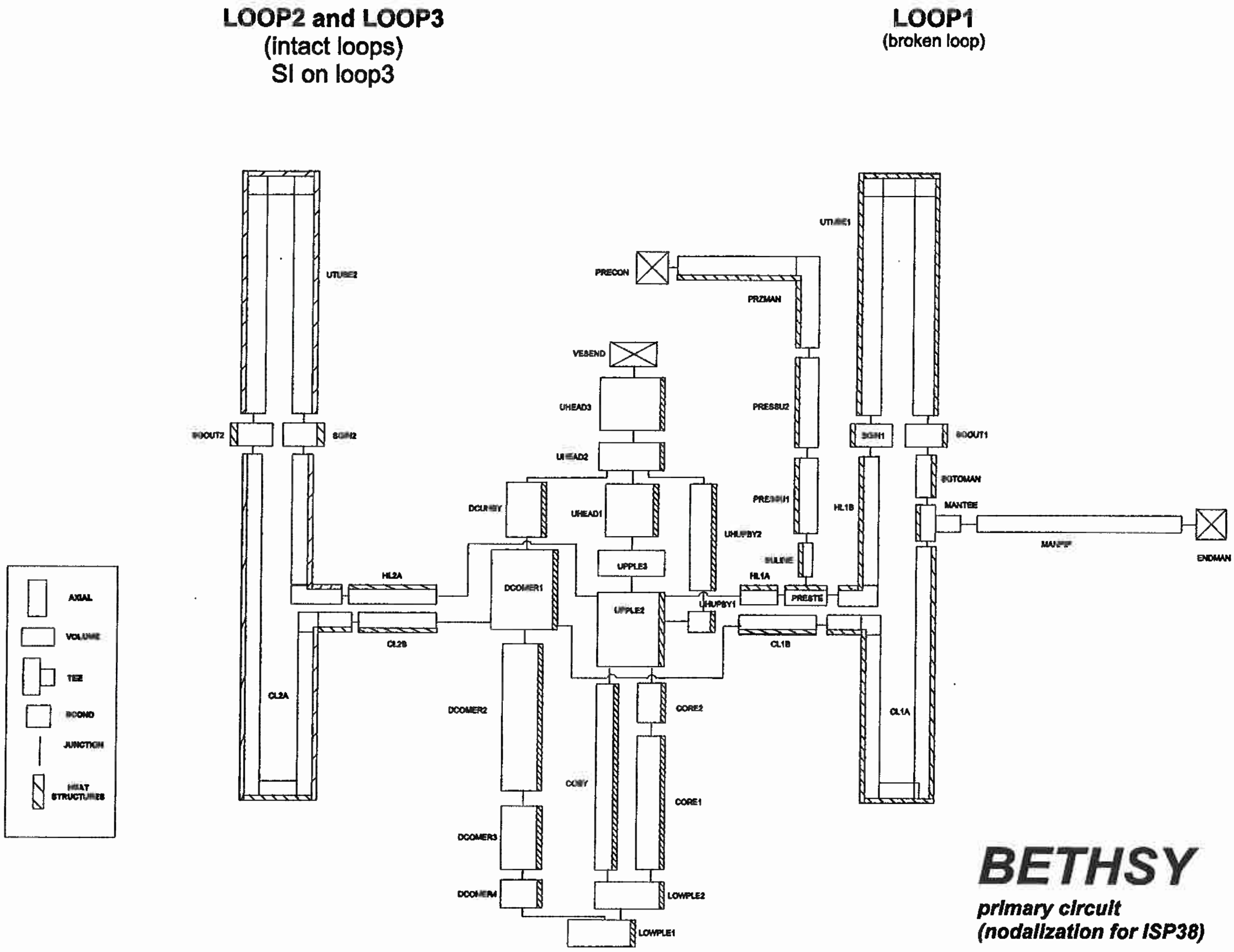


Fig. 13: Sketch of the BETHSY nodalization for CATHARE 2 code, adopted in the analysis of the ISP 38

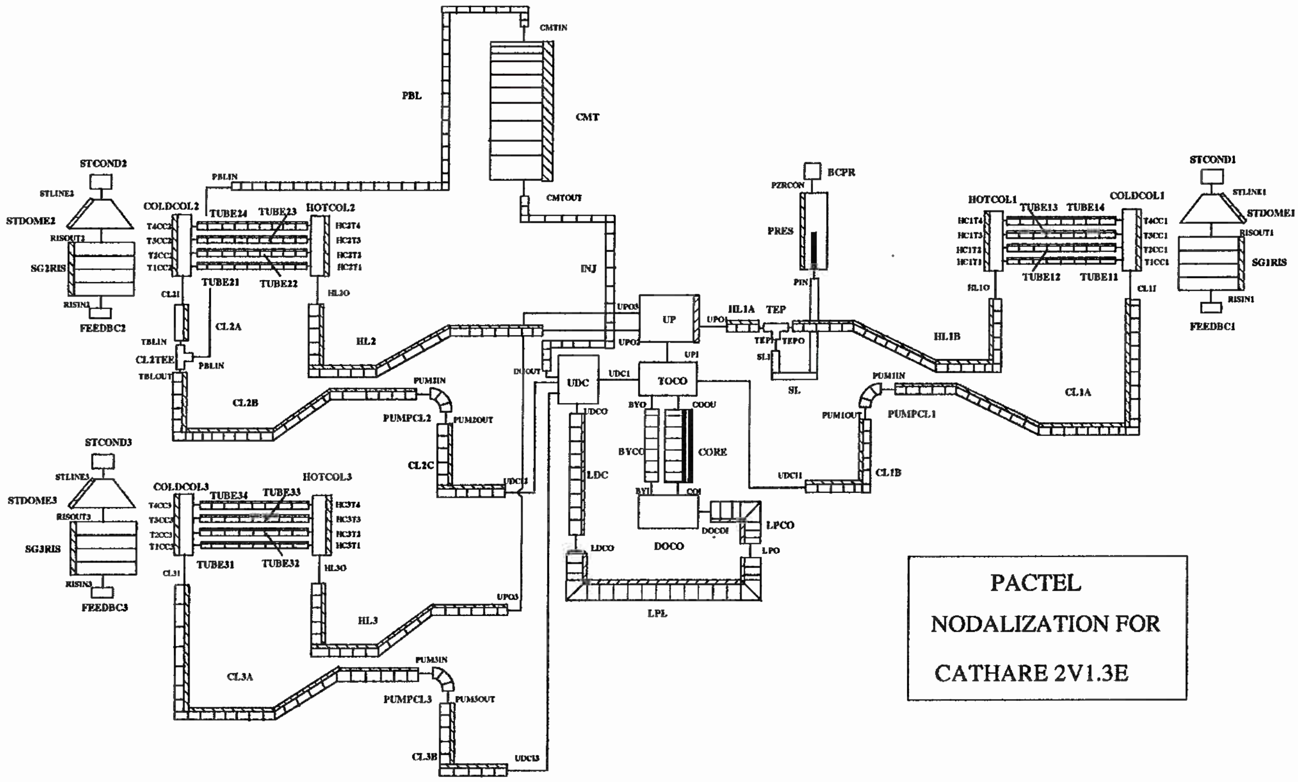


Fig. 14: Sketch of the PACTEL nodalization for CATHARE 2 code, adopted in the analysis of the CMT related experiments

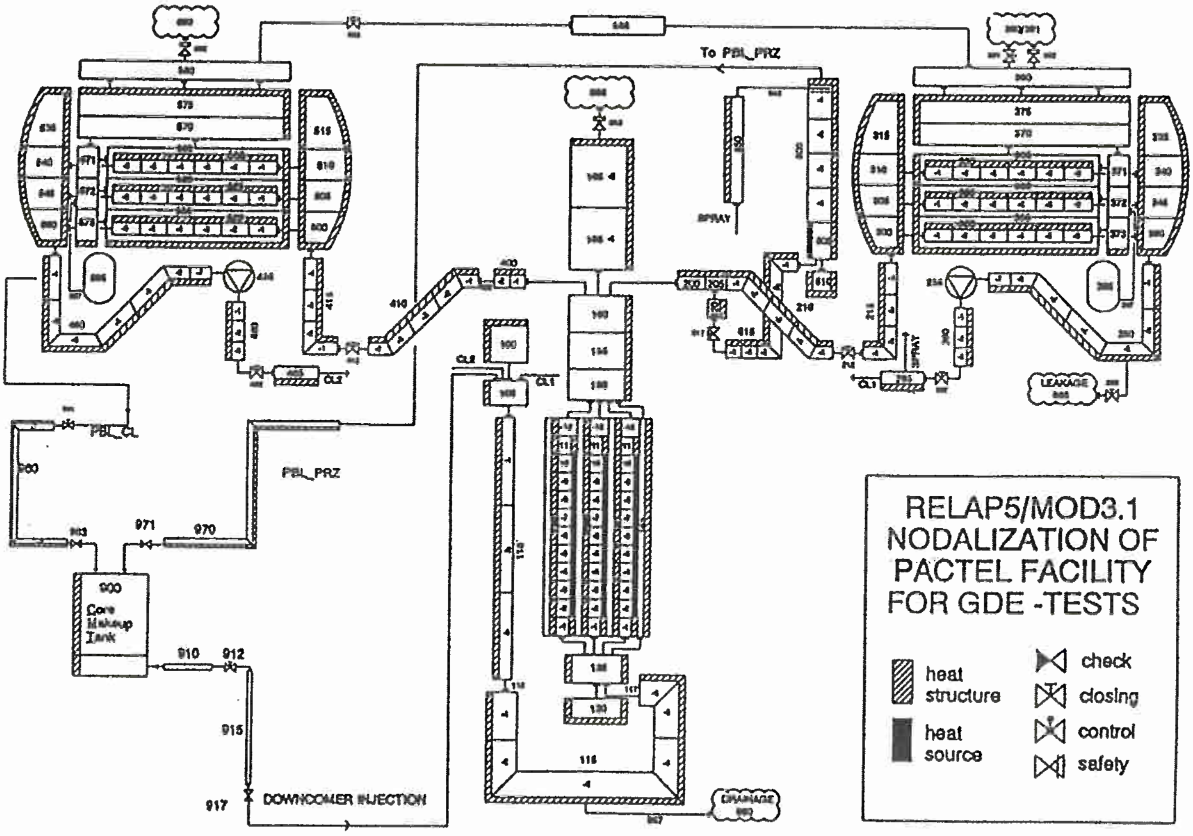


Fig. 15 Sketch of the PACTEL nodalization for Relap5 code, adopted in the analysis of the CMT related experiments

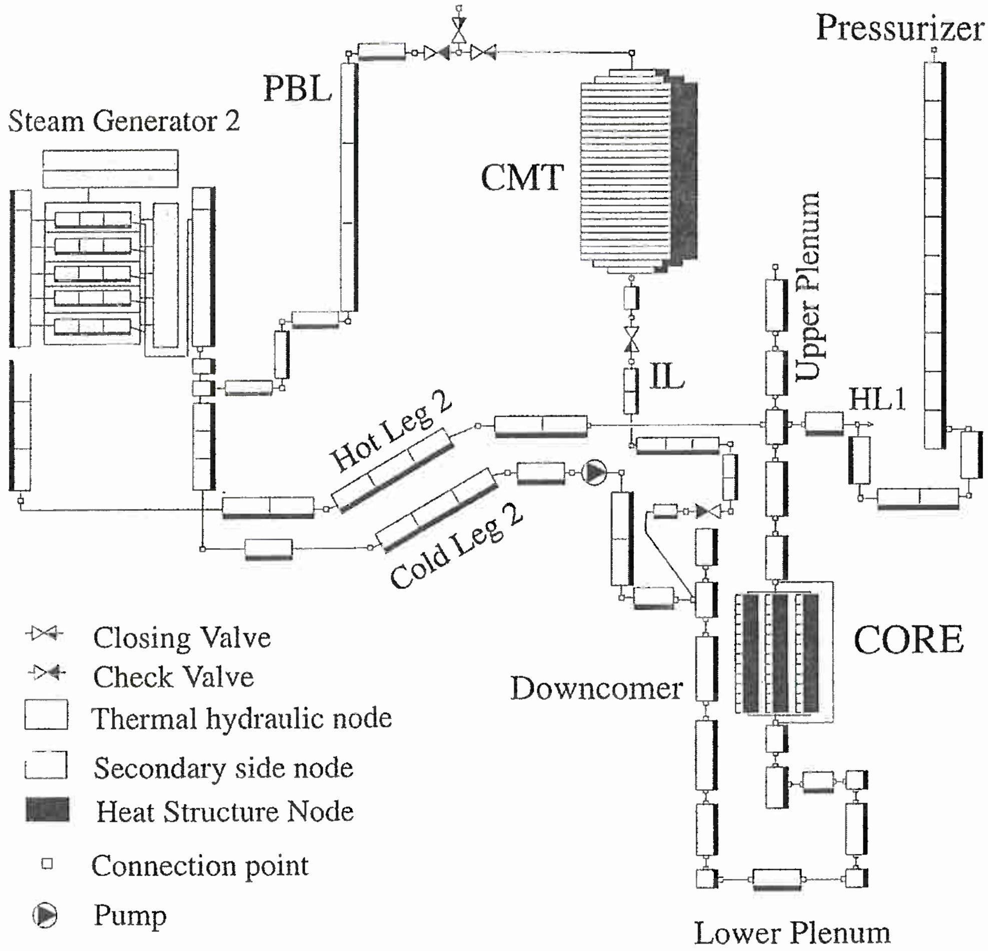


Fig. 16: Sketch of the PACTEL nodalization for APROS code, adopted in the analysis of the CMT related experiments

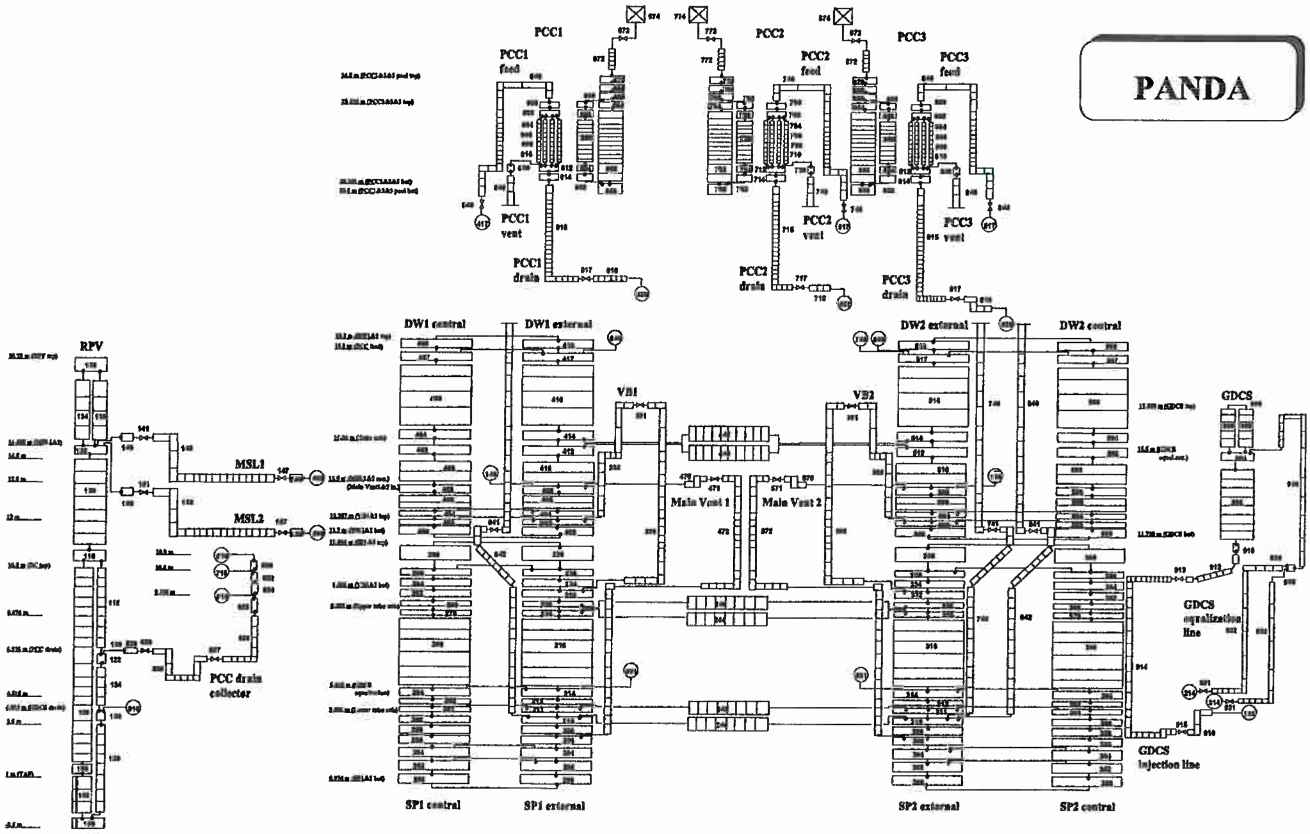


Fig. 17: Sketch of the PANDA nodalization for Relap5 code, adopted in the analysis of the ISP 42

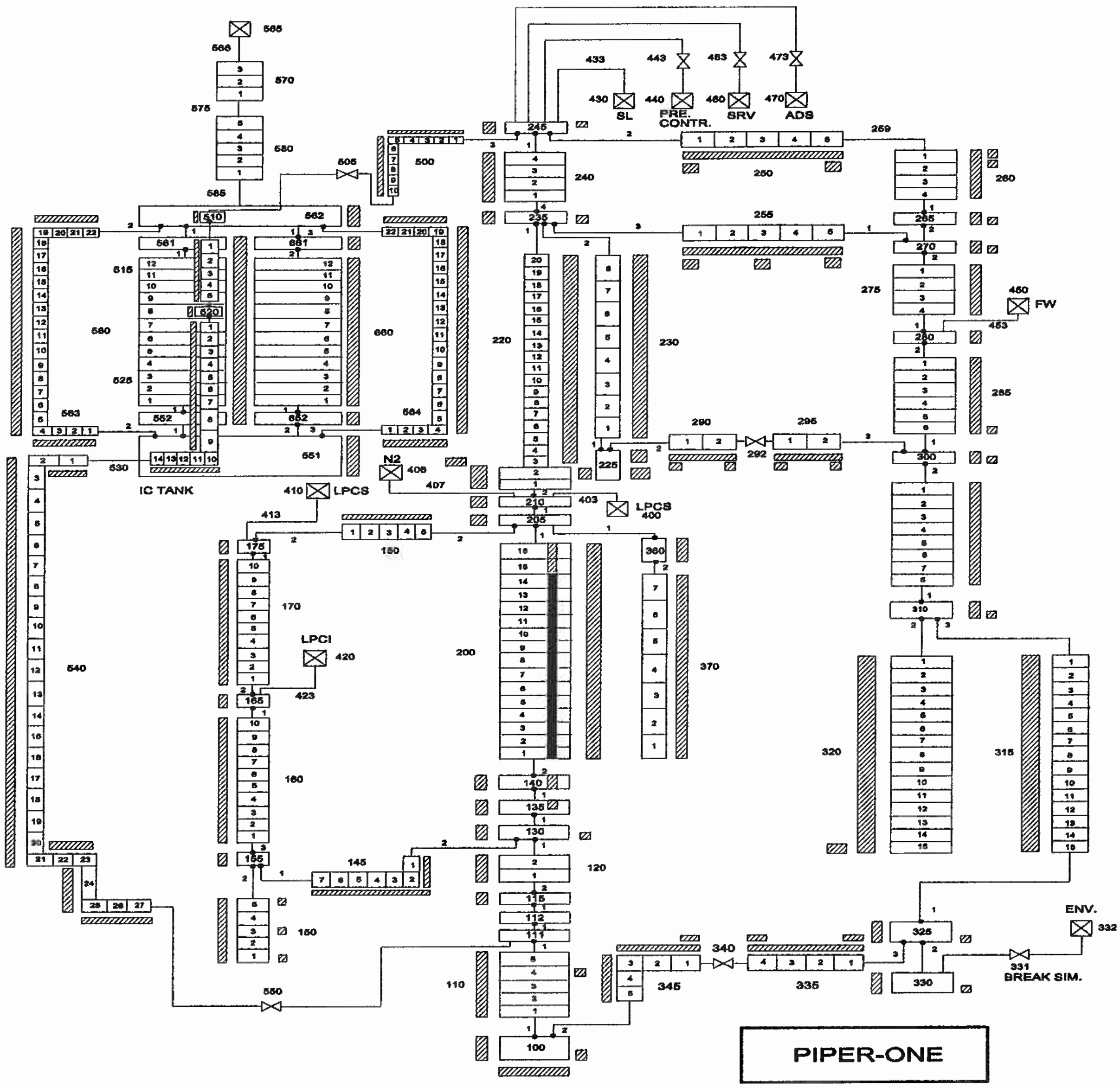


Fig. 18: Sketch of the PIPER-ONE nodalization for Relap5 code, adopted in the analysis of the IC tests

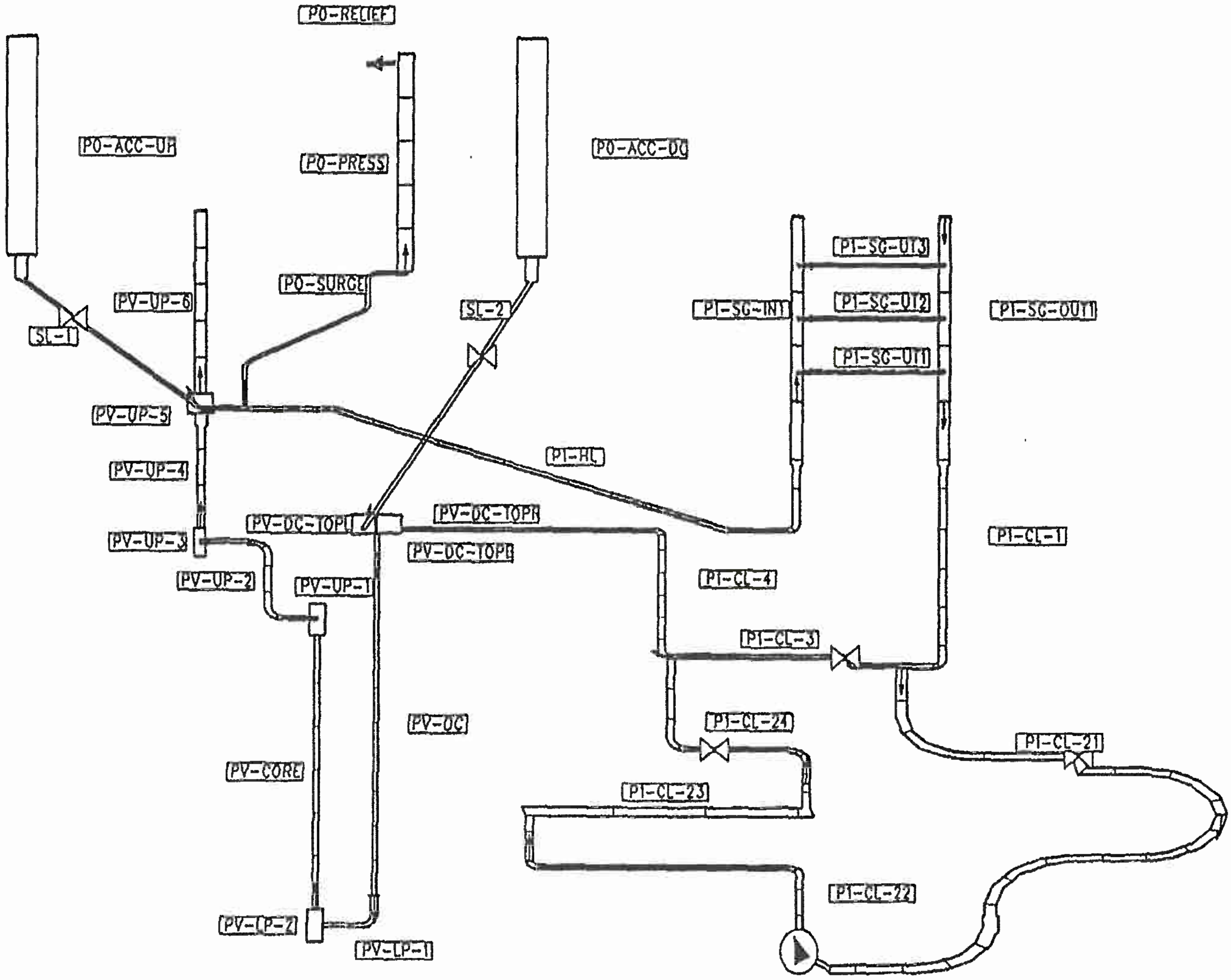


Fig. 19: Sketch of the PMK nodalization for ATHLET code, adopted in the analysis of PMK-tests

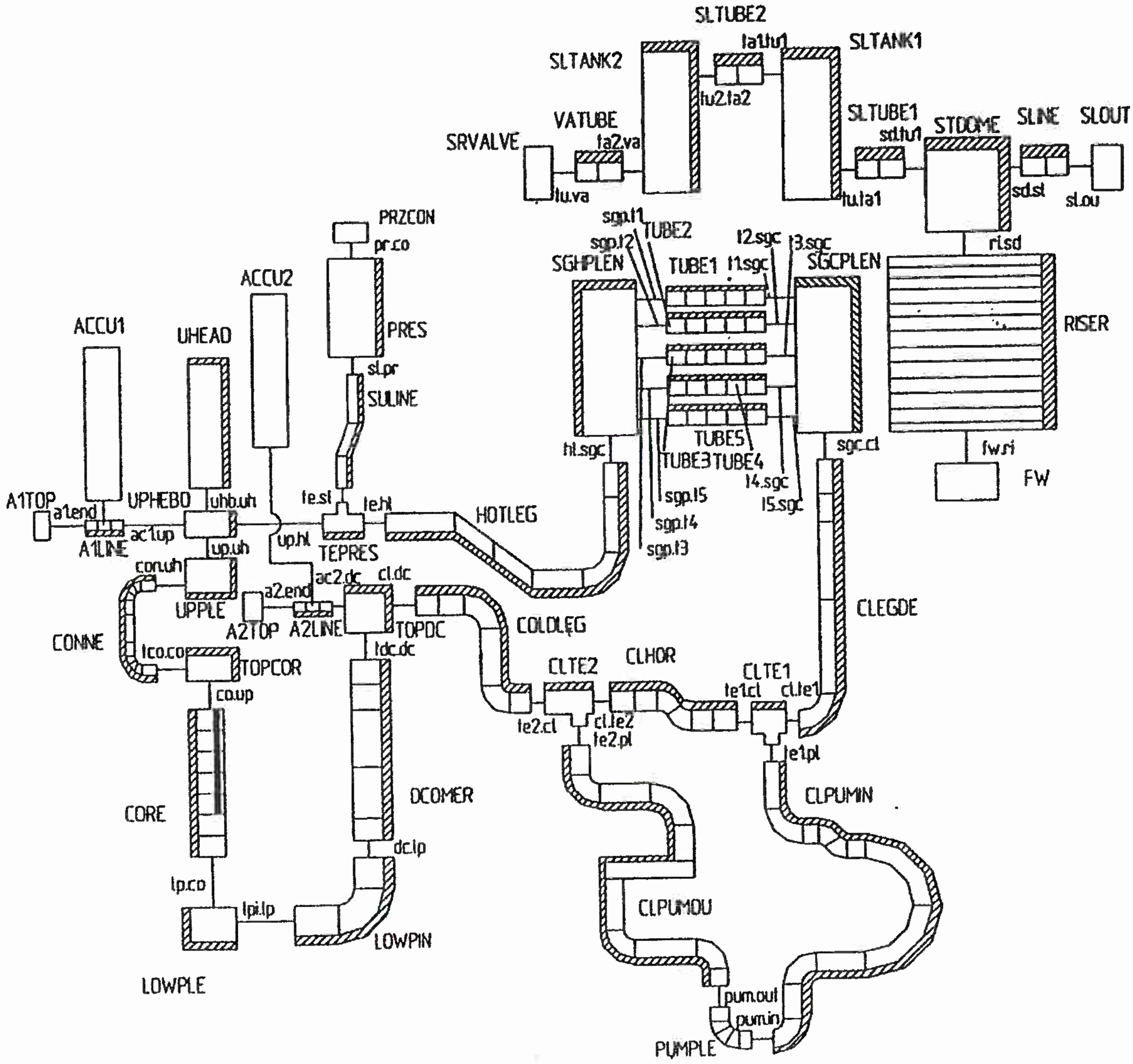


Fig. 20: Sketch of the PMK nodalization for CATHARE2 code, adopted in the analysis of PMK-tests

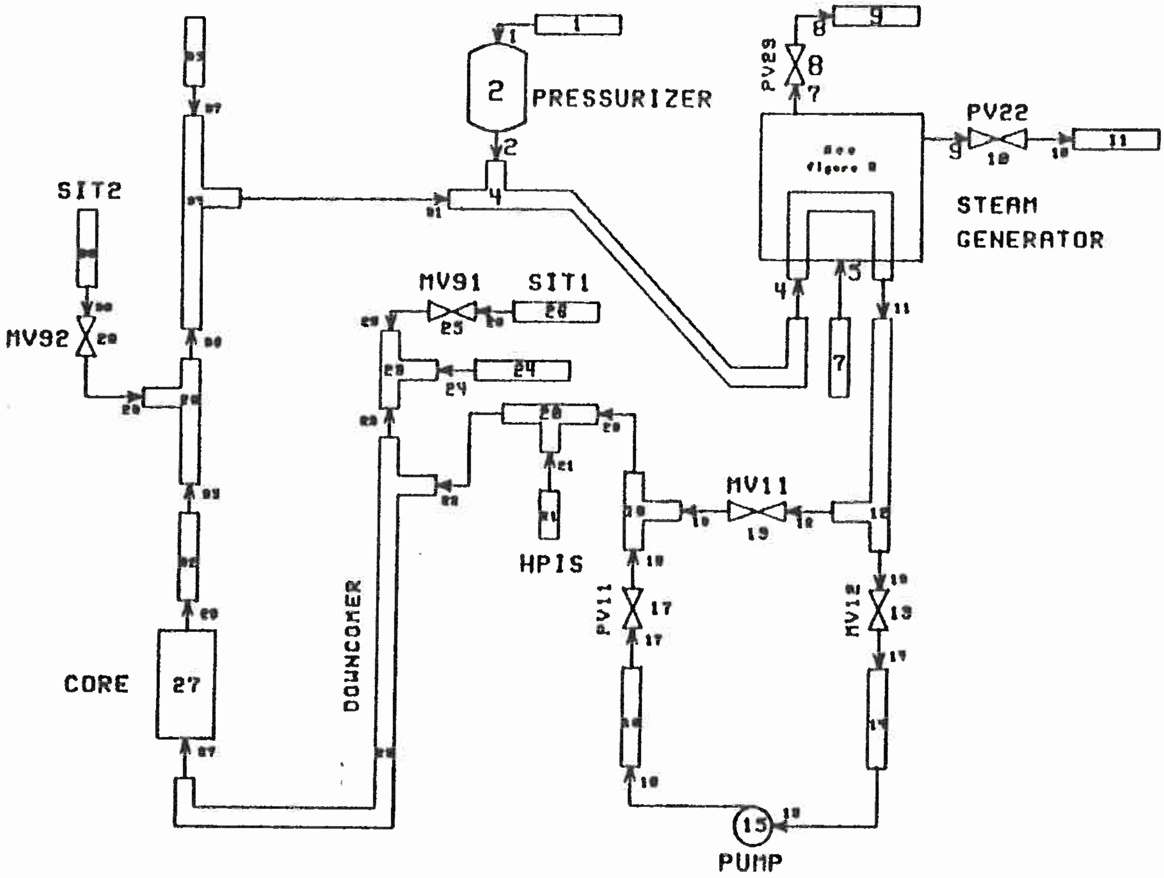


Fig. 21 Sketch of the PMK nodalization for TRAC code, adopted in the analysis of PMK-tests

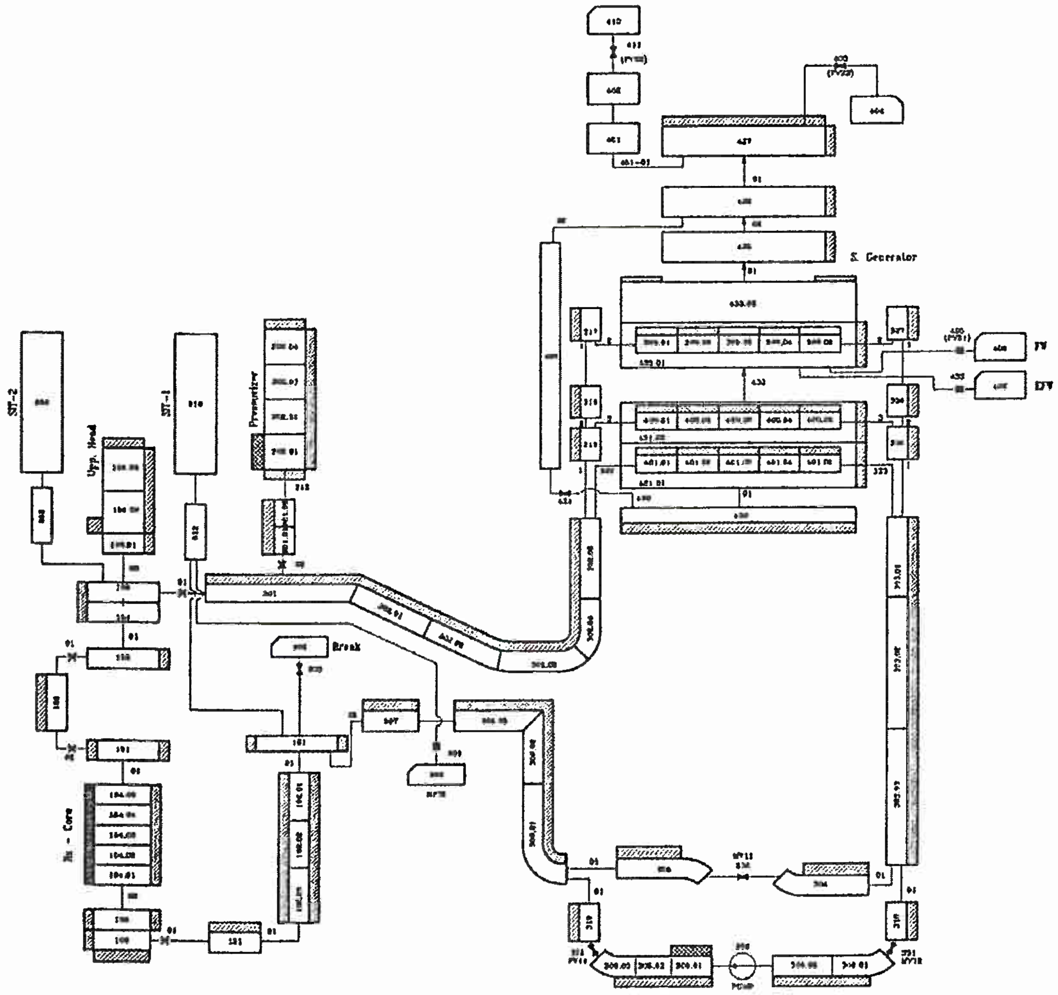


Fig. 22: Sketch of the PMK nodalization for RELAP5 code, adopted in the analysis of PMK-tests

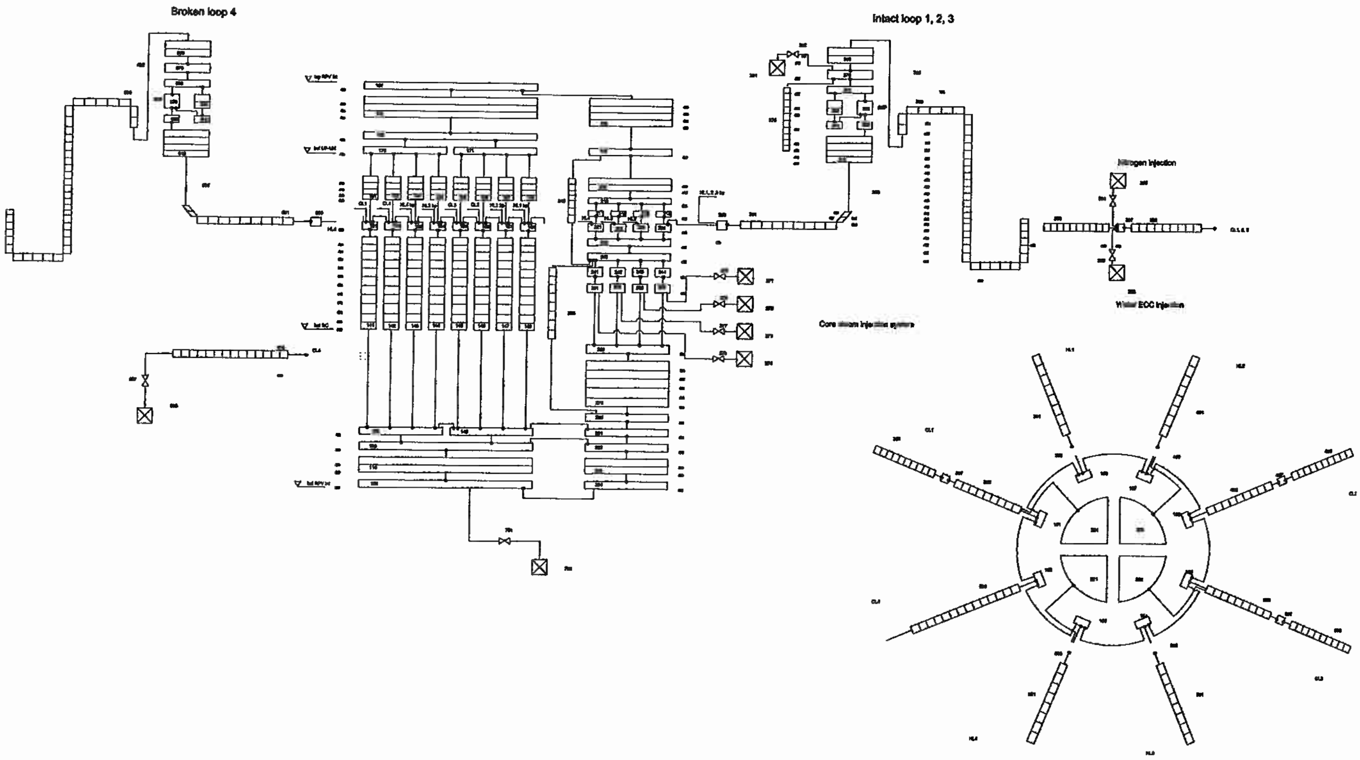


Fig. 23 Sketch of the UPTF nodalization for Relap5 code, adopted in the analysis of refill tests

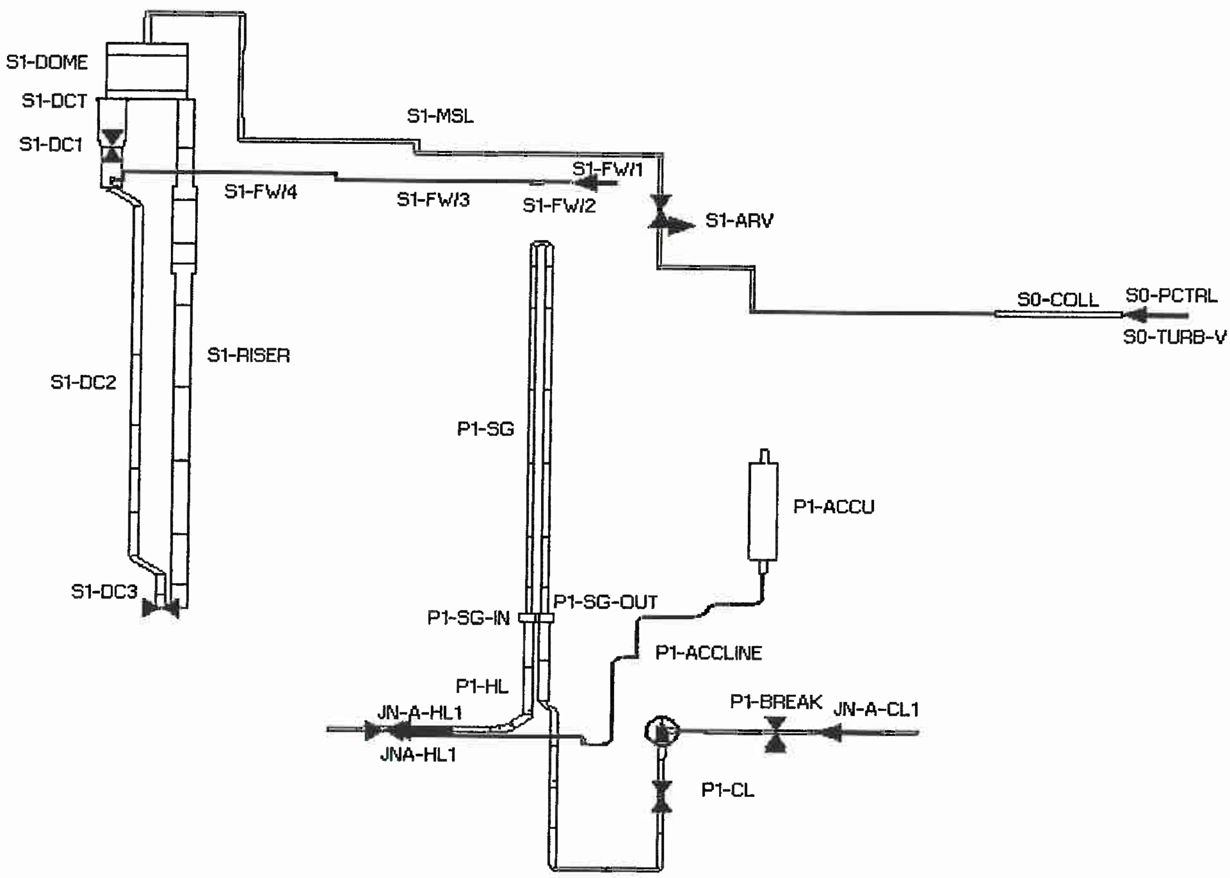


Fig. 24: Sketch of the PKL III nodalization (Loop 1) for ATHLET code, adopted in the analysis of the test PKL III D1.2

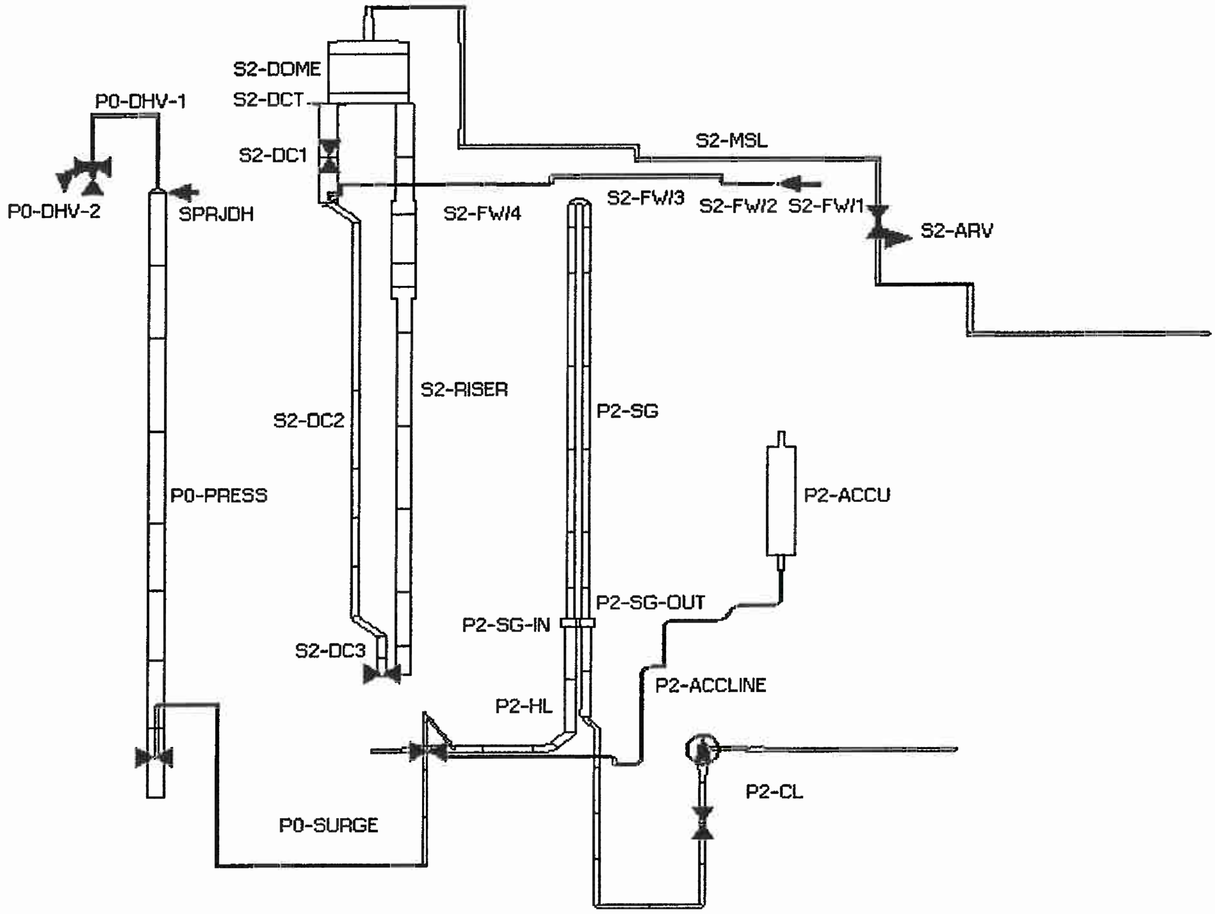


Fig. 25: Sketch of the PKL III nodalization (Loop 2) for ATHLET code, adopted in the analysis of the test PKL III D1.2

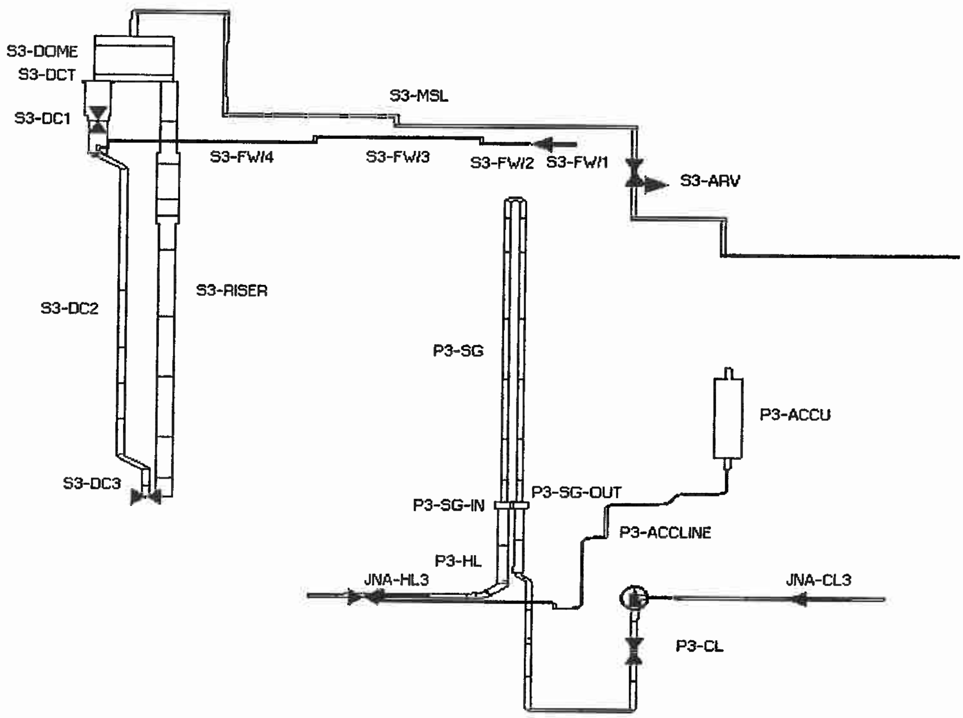


Figure 2.7-15: Sketch of the PKL III nodalization (Loop 3) for ATHLET code, adopted in the analysis of the test PKL III D1.2

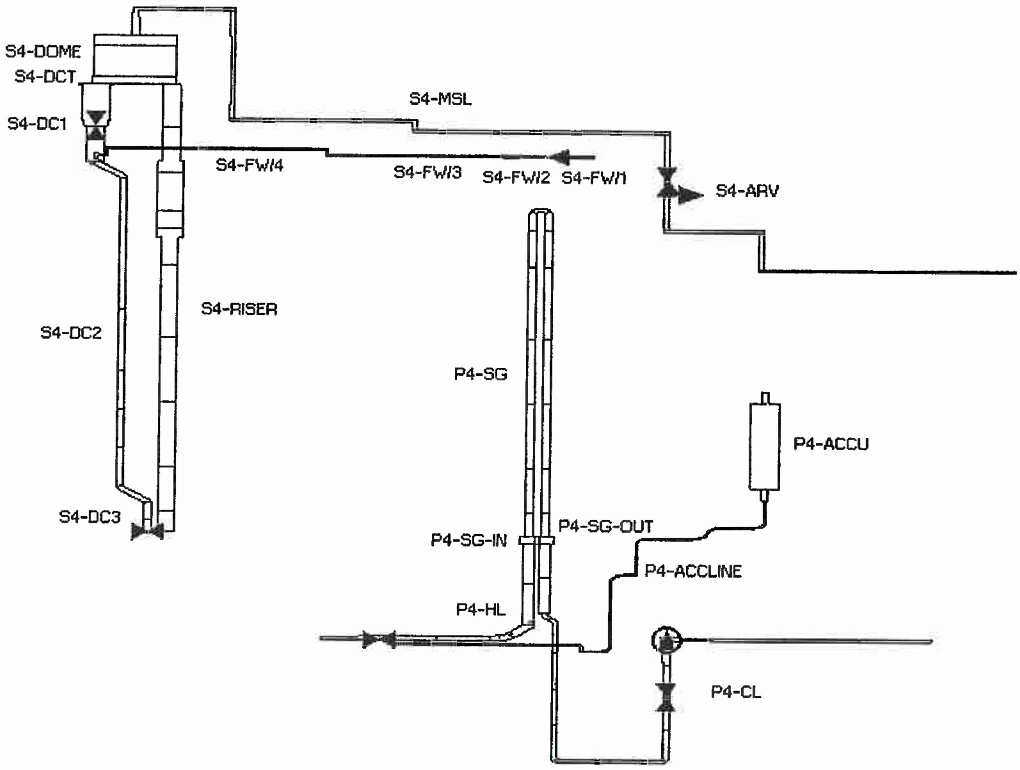


Fig. 26: Sketch of the PKL III nodalization (Loop 4) for ATHLET code, adopted in the analysis of the test PKL III D1.2

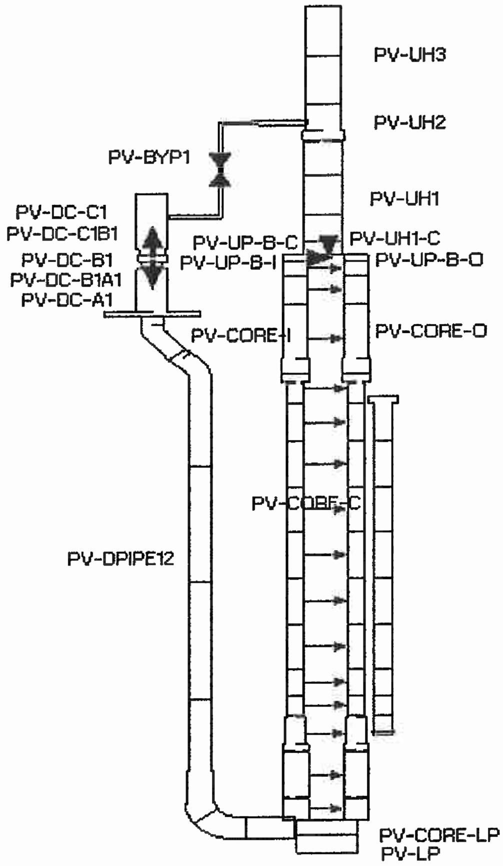


Fig. 27 : Sketch of the PKL III nodalization (Pressure Vessel) for ATHLET code, adopted in the analysis of the test PKL III D1.2

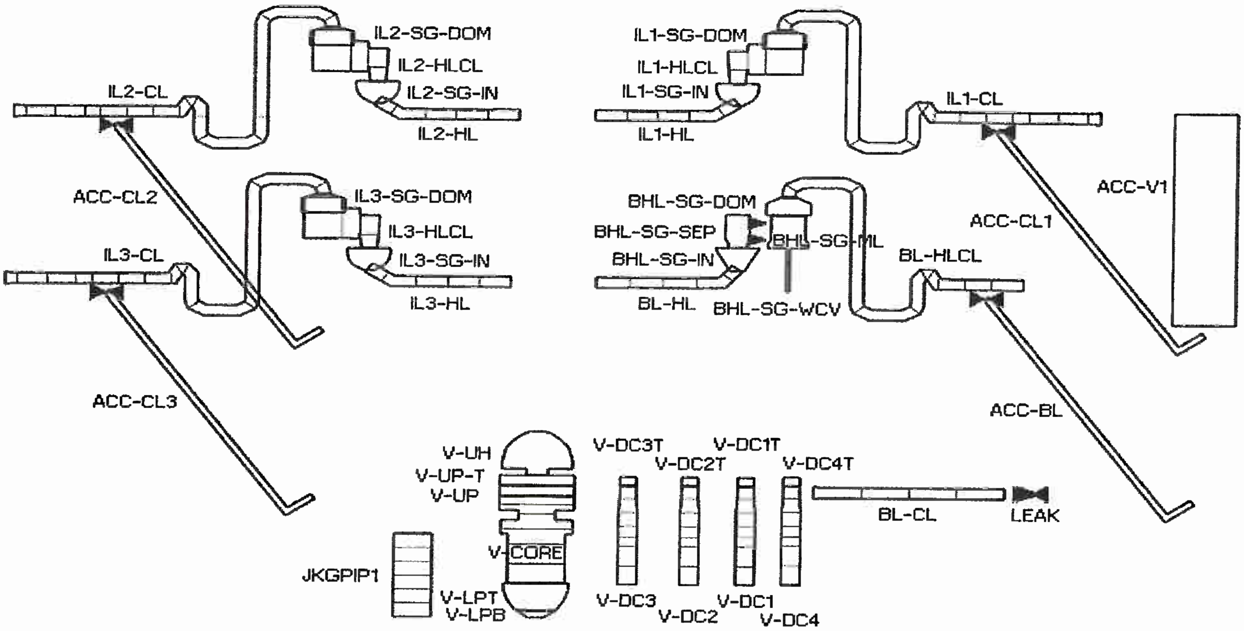


Fig. 28 : Sketch of the UPTF TRAM nodalization for ATHLET code, adopted in the analysis of the test UPTF TRAM A6

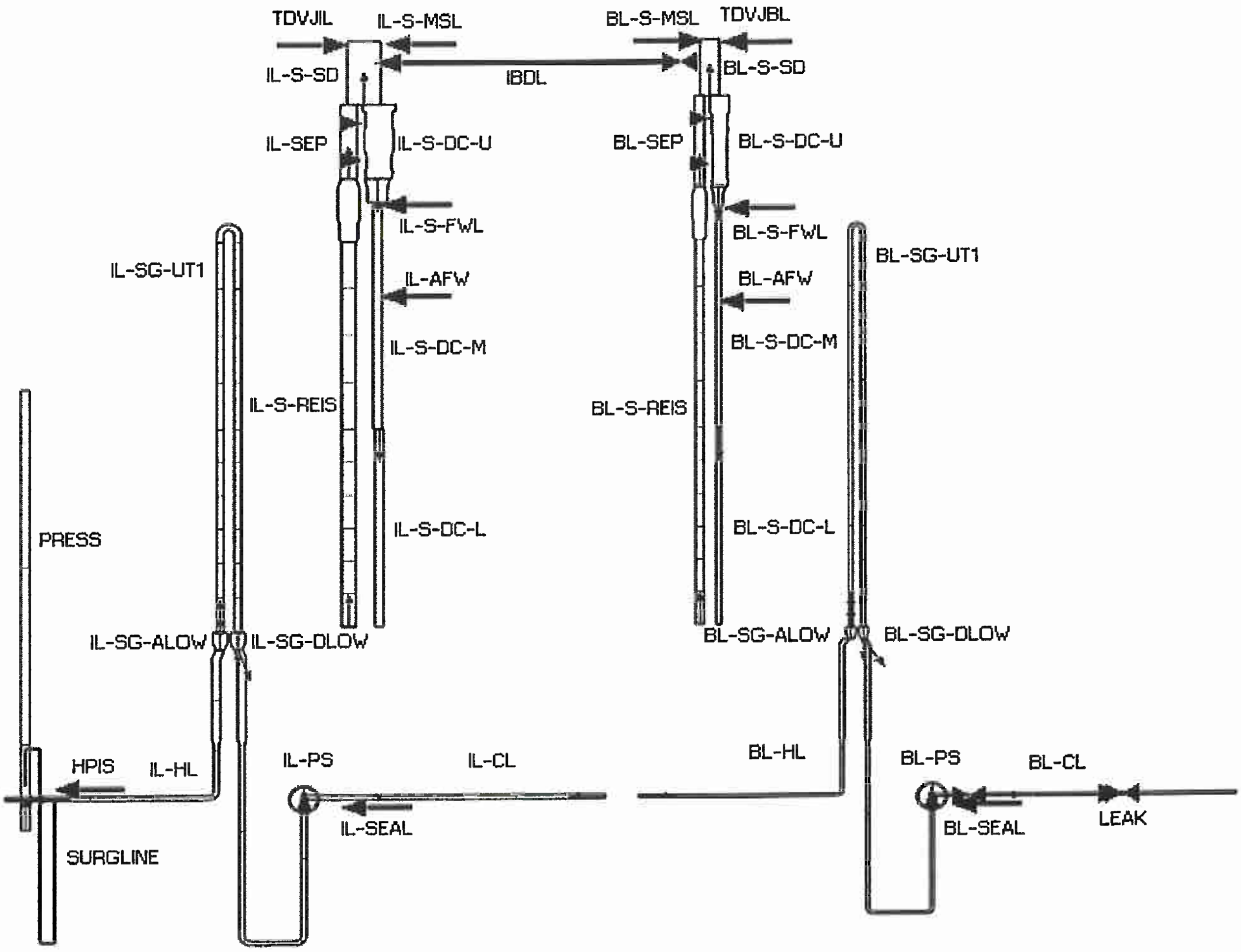


Fig. 29: Sketch of the LOBI MOD2 nodalization (Loops) for ATHLET code, adopted in the analysis of the test LOBI A1.82

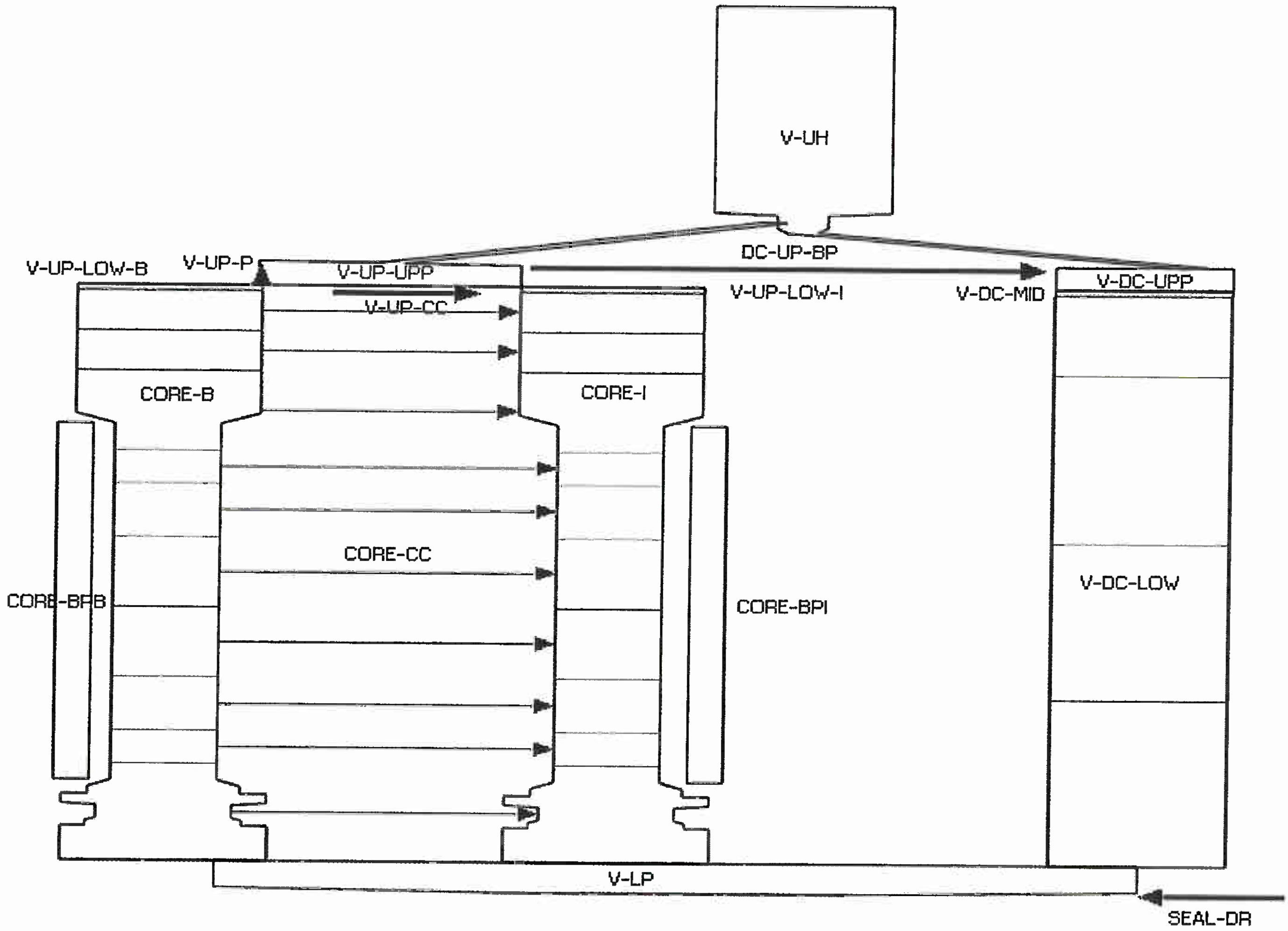


Fig. 30 Sketch of the LOBI MOD2 nodalization (Pressure Vessel) for ATHLET code, adopted in the analysis of the test LOBI A1.82

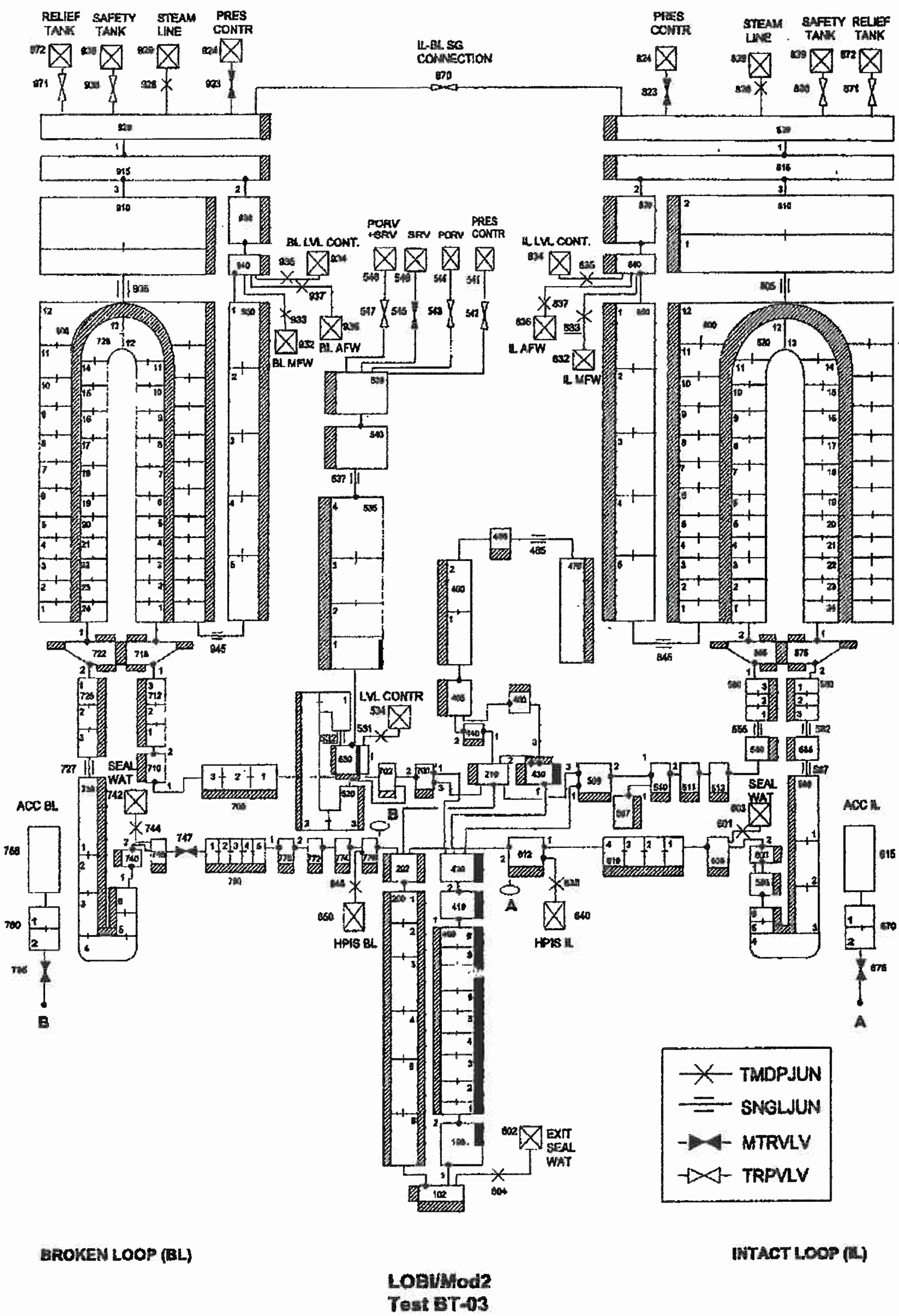


Fig. 31 Sketch of the LOBI MOD2 nodalization for Relap5 code, adopted in the analysis of the BT-03 test

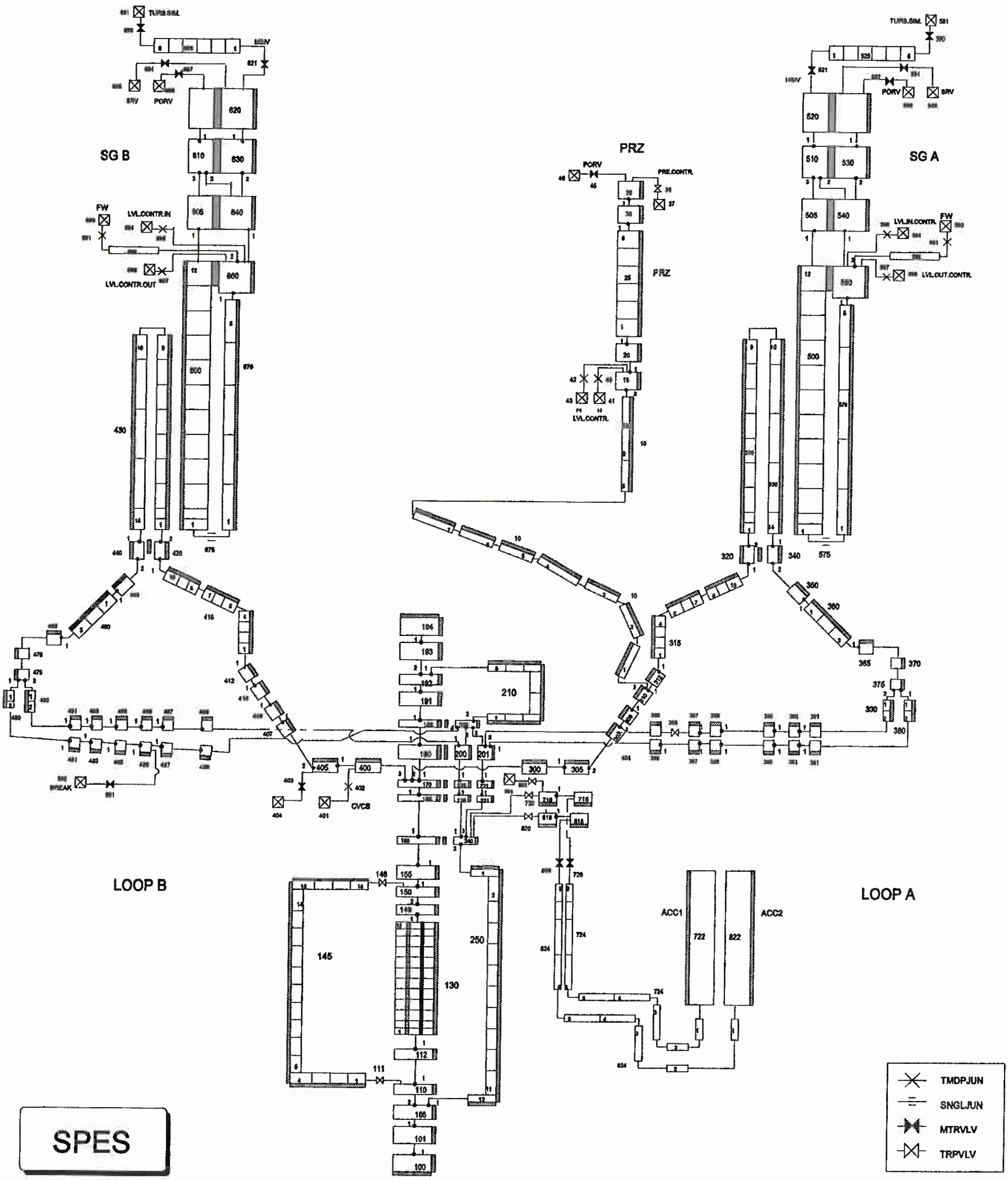


Fig. 32: Sketch of the SPES-99 nodalization for Relap5 code

4 Development and establishment of the CERTA Network Database

4.1 CERTA-TN Database Reference

The establishment of a user-friendly, web-based distributed informatic platform based on modern information technologies and provision of a demonstration package for remote data access and retrieve was the primary objective of the CERTA project [4 - 5].

As structured, the CERTA-TN includes experimental programs and databases relevant to reactors in operation within the EU member countries as well as to reactors in operation within the Central and Eastern-European Countries and the New Independent States. Fig. 33 - shows the geographical distribution of the participants in the CERTA-TN.

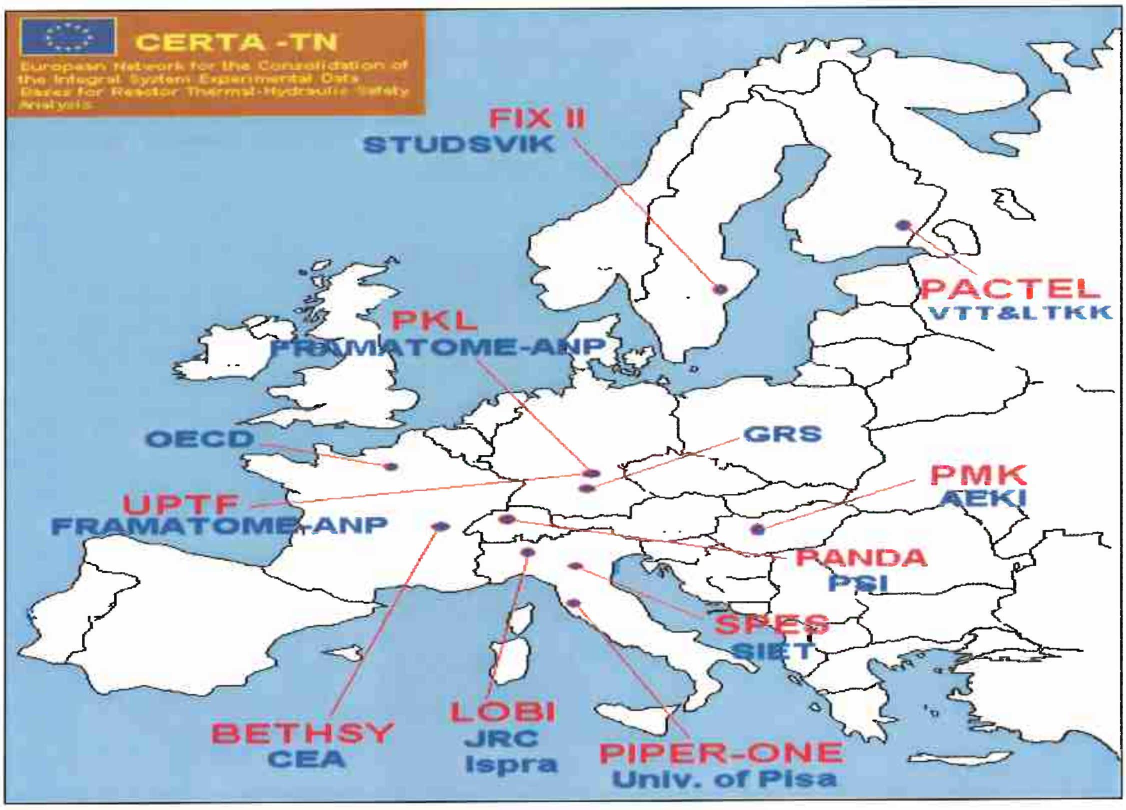


Fig. 33 - Geographical distribution of the CERTA partner

4.2 Description of CERTA network

CERTA is a network of databases related to the facilities indicated in Tab. 1. These are the European major integral test facilities. For each of the organizations listed here a dedicated web site has been prepared which contains the data and the documentation of at least two experiments per facility.

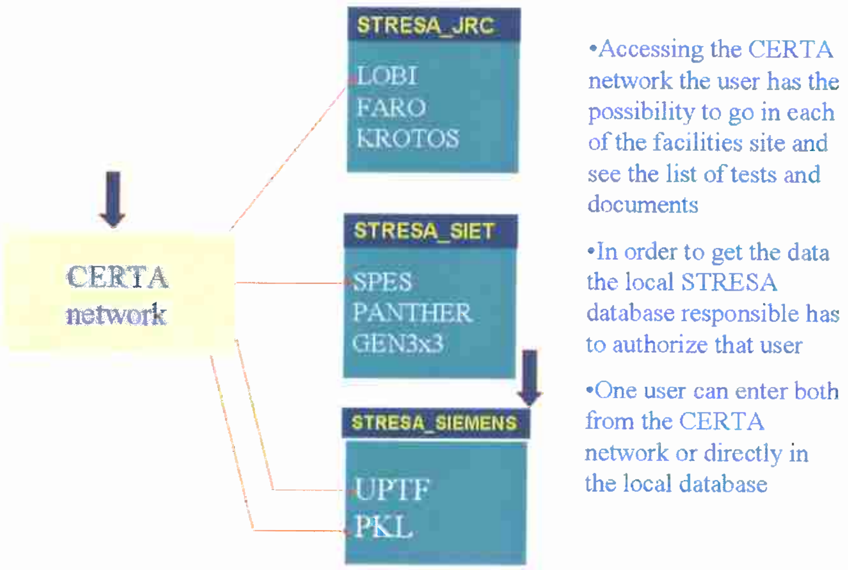
Table 34 - European LWR Integral System Test Experimental Programs

PROGRAMME	DENOMINATION	ORGANISATION	COUNTRY
PKL	PrimaerKreisLäufe	Framatome ANP (Siemens/KWU)	Germany
BETHSY	Boucle d'Etudes Thermohydraulique Système	CEA (Grenoble)	France
SPES	Simulatore PWR per Esperienze di Sicurezza	SIET - Piacenza	Italy
LOBI	Loop Off-normal Behavior Investigations	JRC - Ispra	EC
UPTF	Upper Plenum Test Facility	Framatome ANP (Siemens/KWU)	Germany
PIPER-ONE	BWR Simulator	Pisa University	Italy
PACTEL	VVER Simulator	VTT Processes /Lappeenranta University of Technology (LTKK)	Finland
PMK	VVER Simulator	KFKI	Hungary
FIX-II	BWR Simulator	Studsvik	Sweden
PANDA	Passive Decay Heat Removal and Depressurization Test Facility	PSI - Villigen	Switzerland

A portal has also been built, accessible at the following internet address:

http://asa2.jrc.it/certa

from which is possible to navigate in all the other web sites with one single user-ID and password. The software adopted for such web site is the STRESA Database, developed at JRC Ispra, which will be described in the next chapter.



The advantage of such solution is that the responsibility of the release of the data and documents is at the level of the organizations that own the data and not at central level, as in other types of network databases.

In order to build the various databases it was necessary a small training period, that is described in the following chapter after which all the participants were able to install the dabase in their own web servers.

4.3 The STRESA Database

In order to fulfill the object of preservation of experimental databases and the maintenance of supporting information/documentation a new database called STRESA [6] has been developed at JRC with the following specific requirements:

- The database has to be accessed via Internet
- Access to data is to be controlled
- Access authorization to specific documents is performed locally, by responsible of data, not by delegated entities
- If needed, the data can be stored in various servers computers across the network

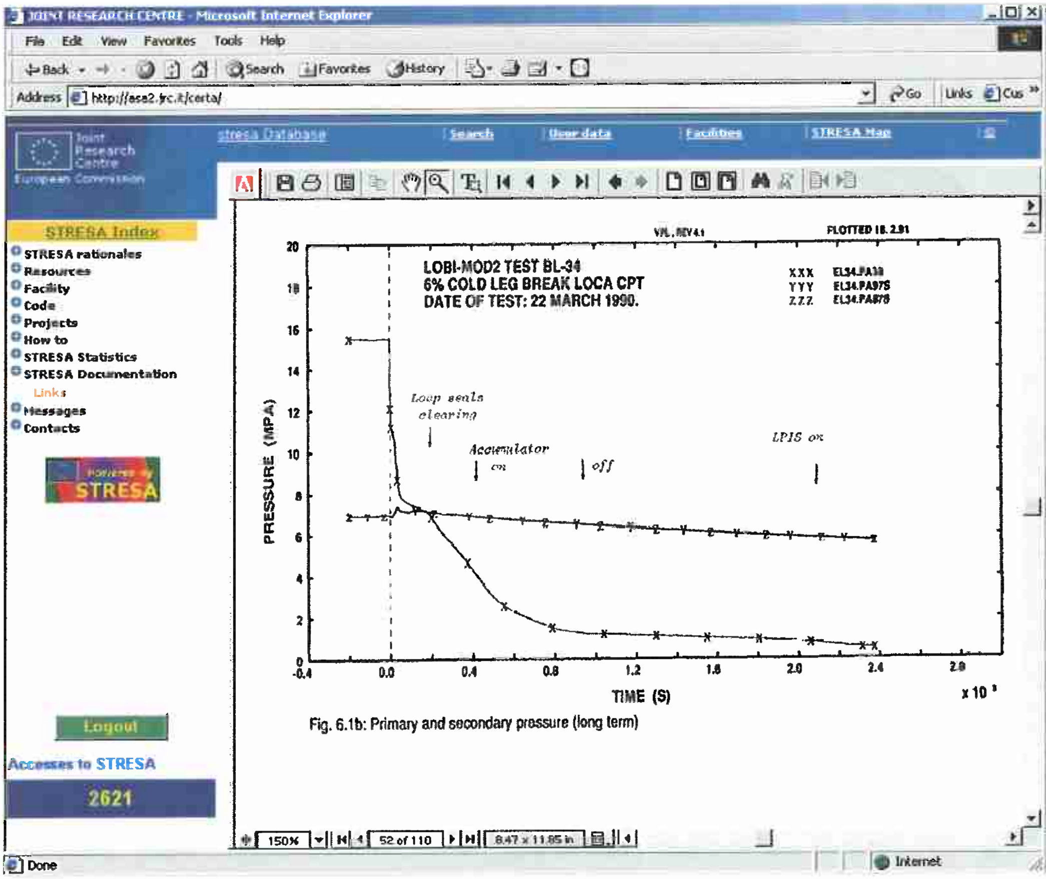


Fig. 35 - Reproduction of a LOBI Quick look report

STRESA is a general-purpose database to store documents and data coming from any type of plant or experimental facility as well as from code calculations. Fig. 35 shows an example of document stored in the STRESA structure.

The arrangement is indicated in Fig. 36: the user can connect via Internet to a server that will access to a database containing the data. This is the so-called three-tier arrangement, in which the access to the data is dedicated to the server, which is detached from the real data.

The main components of the STRESA database are:

- The files on the disk

- The Access database
- The html-asp pages

4.4 The database files

For a specific choice the files, which are to be stored are kept in their original format on the computer disk: ©Microsoft Word files, or ©Adobe pdf files, AVI or MPEG file for the films and so on. These files are not included in the Access database to allow a better maintenance (if new versions of the reading programs will come out, they can be easily converted). If, as an alternative, the documents were included in the Access database they were going to be embedded in the proprietary Access matrix structure, difficult to be updated: a potential data file corruption could involve all the data in the database.

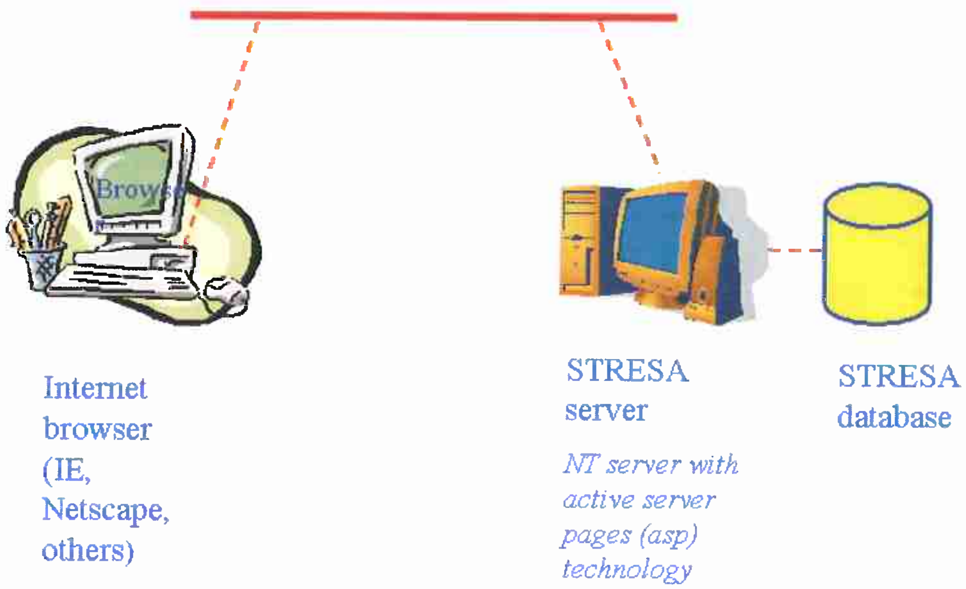


Fig. 36 - The three-tier arrangement adopted for the STRESA database

The only exception to the preservation of the original format is for the data files, which are stored with a method developed at JRC called WinGraf mode (see appendix A). If the data are stored with this mode it is possible to benefit of the on-line plotting procedure, as presented in Fig. 37. The plot reported here is performed on-line, on user request, which can therefore customize it to its preferences.

If the data are not stored with this format the user can still download the data but he cannot visualize on-line the plots on the screen.

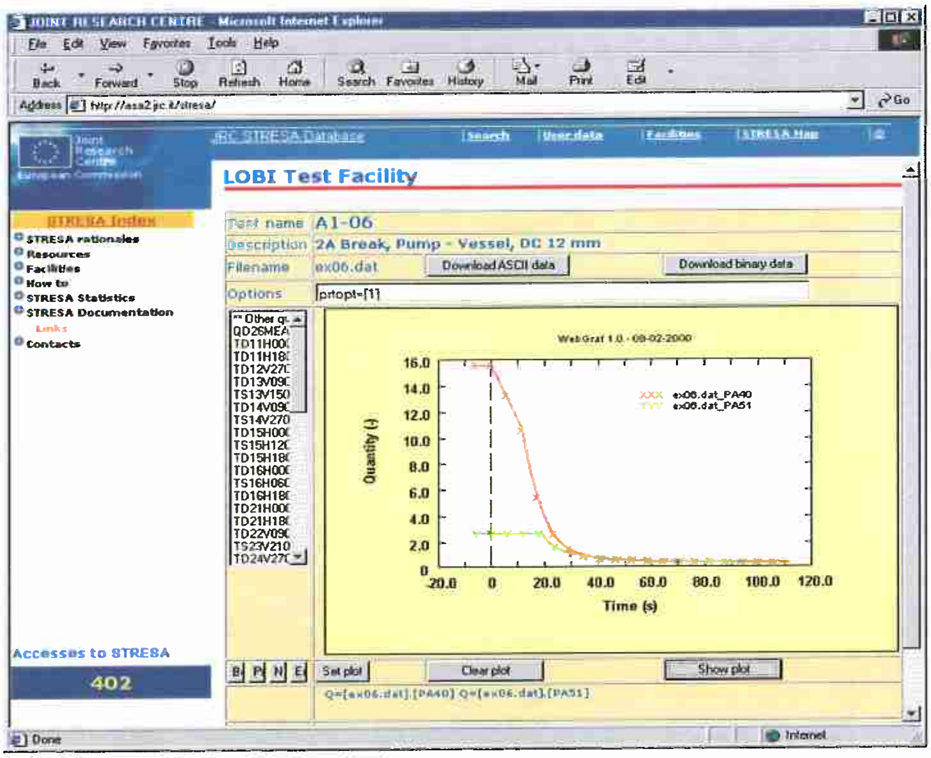


Fig. 37 – Example of plotting signals

4.5 The Access Database

A Microsoft Access Database is used to keep memory of the physical position on the disk of the electronic documents (drive and filename) and document properties such as Facility and Test Name. The documents can therefore be accessed in hierarchical mode. An example for experimental facilities may be:

Facilities → Tests → Documents

It is thus possible to have a number of Test facilities, which have produced a number of tests. For each of these tests an arbitrary number of documents may have been stored[1].

The subdivision adopted here is arbitrary: the webmaster can decide a different one. Another example could be referred to computer codes:

Codes → Versions → Executables

Other main tables contained in the database are the list of users, the authorization tables, list of events, etc.

4.6 The html-asp files web pages

The user interface is obtained by a series of user-friendly accessible web pages which allow the retrieval of the information, the plotting of experimental data points (Fig. 37) or the visualization of films or images. Fig. 38 shows the list of documents produced for one

1.1.1.1

[1] One document may have been produced also for more than one test, even related to different facilities.

particular LOBI tests. If the user has enough authorization he can see the documents and/or download them. The Quick Look Report and the Experimental Data Report, scanned from the original documents, are now easily accessed on-line.

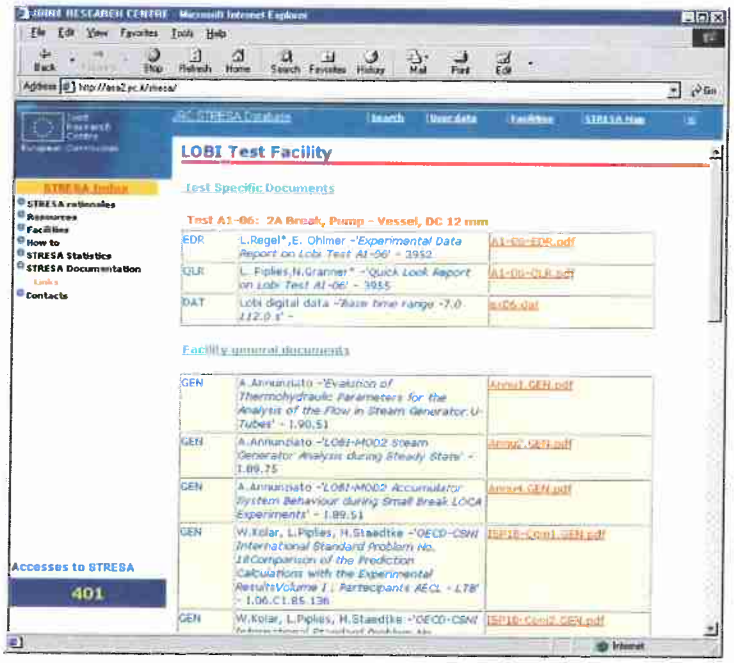


Fig. 38 – List of documentation available for a specific LOBI Test

Fig. 39 shows the collapsed liquid level in one particular LOBI test at the time when the loop seal is cleared. This type of films is very useful when analysing complex experimental sequences in which the water masses are moving within the test facility. X-y plots are less intuitive and difficult to analyze.

As an additional example, Fig. 40 shows a film obtained in the FARO facility which illustrates the initial molten UO_2 jet just before entering the water. This type of film has been very useful in assessing the real form of the jet and excluding previous hypotheses on the molten jet dispersal (jetpre- pre-fragmentation in the gas space was assumed in some models).

4.7 Entry in the Database and Authorizations

As a new user registers in the database, he receives a password via e_mail, which allows entering and seeing the list of documents produced. He cannot get any file, unless the database responsible has declared a document as free available (level 0). In order to access a specific document the user can make a request via e_mail specifying which document he wants to access.

The responsible of data release, clearly indicated on each page, can give authorization to that user allowing him to get: (a) one particular document, (b) all the documents of a particular test or (c) all the documents of a particular test facility.

Once the user gets this authorization, that normally does not take more than a couple of minutes of working time, he is enabled to download the requested data.

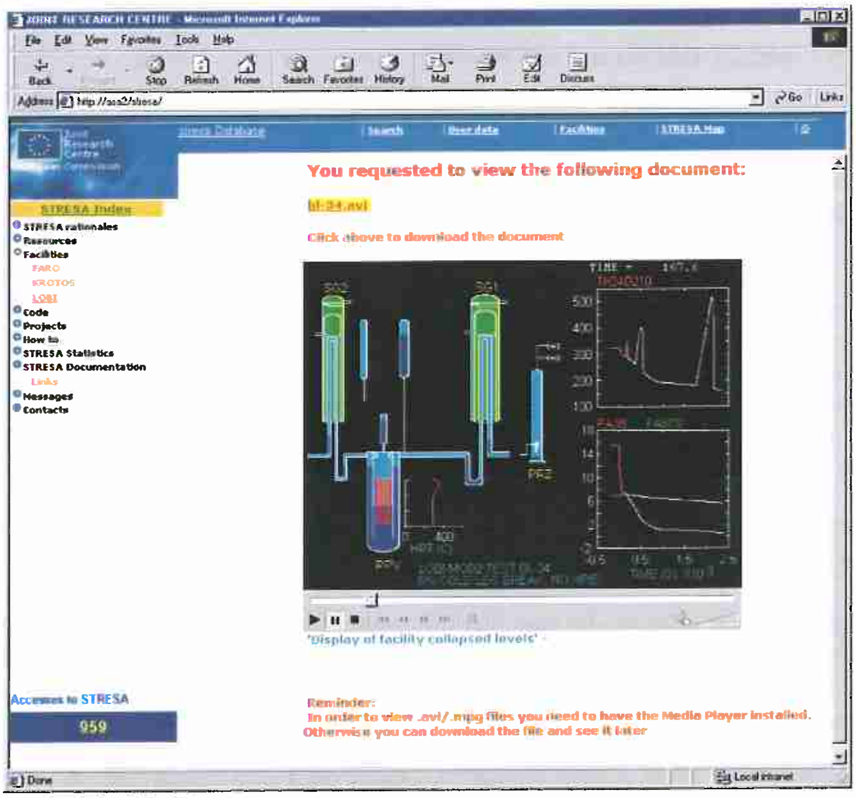


Fig. 39 – Display of measured collapsed levels in the LOBI facility during Test BL-34. It is possible to identify the time of loop seal clearing which determines a temporary core rewetting.

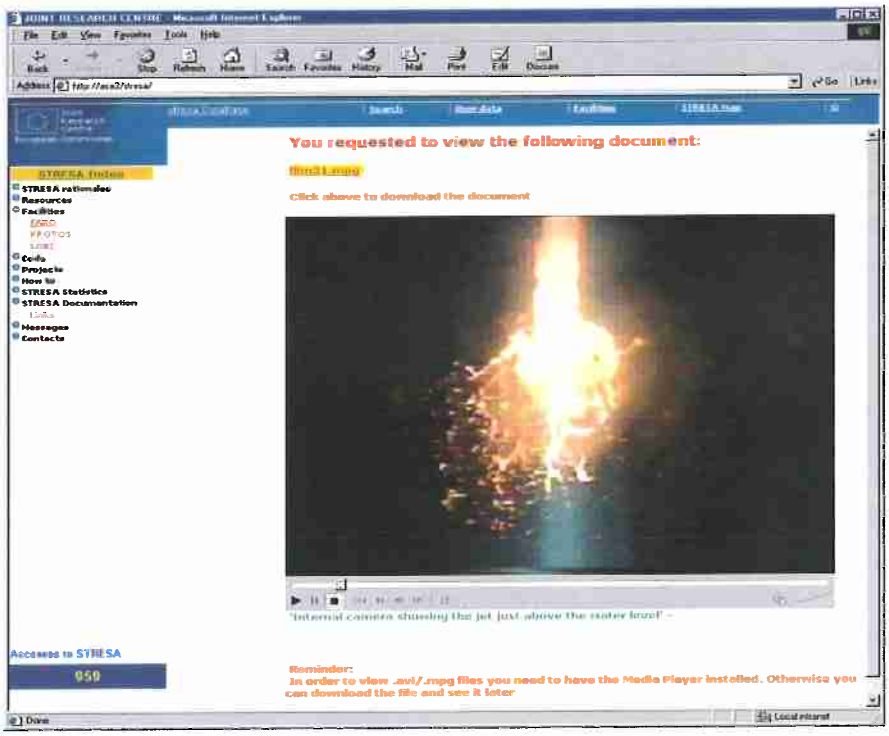


Fig. 40– A film performed during a FARO test which shows the initial portion of a molten UO2 jet at about 3000 K just before entering the water pool

4.8 STRESA database networks

A major characteristic of the STRESA database is that it can also be configured as a **network** database with a number of **local databases**. From the central database, it is possible to make connection with other local STRESA_like databases thus forming network of databases, which increases the potential and the power of this type of storing system.

As the user is registered in the initial database, so called "portal", he gets a list of facilities or codes or whatever is present in the portal itself or in another connected database. If the facility is located in an external database in the Internet network (say STRESA_x), during the linkwhen the user connects with the remote server, he is recognized by the STRESA_x database as a user coming from a STRESA node and is allowed to enter. However, when he enters, if not specifically authorized by the responsible of the STRESA_x database he will only be allowed to view the list of documents produced for that particular facility.

The relevant point is the fact that the authorization to download data is given by the responsible of the STRESA_x database and not by the portal responsible.

Another important point is the fact that the responsible of the STRESA_x database has to permit the portal users to reach his database. If, for any reason, the conditions for the access are missing, it is sufficient to remove that portal from the list of allowed portals to prevent this occurrence.

As a final remark, it is possible to conceive more than one network based on the same or different databases, either thematic or of any other purpose. As an example, the JRC STRESA contains LOBI, FARO, KROTOS and COMETA documents. The LOBI can be part of a thermohydraulic network and FARO and KROTOS could be part of a FCI network.

An agreement is under way with OECD-NEA to adopt STRESA as database structure for the Computer Code Validation Matrix (CCVM), which has been defined and stored in the NEA headquarters in Paris.

Other European institutions (e.g. ENEA-I and FZK-D) are also adopting the STRESA structure, which offers great advantages in terms of data and documentation management, storage and retrieval as well as networking potentials.

4.9 Security considerations

Although the data contained in scientific databases do not constitute per-se a serious risk potential. In our opinion the major risk is constituted by the loss of data due to obsolescence of storing media or loss of conversion tools, loss of people with knowledge of the data, etc.

Since however the data have an indoubt intrinsic value the attempt has been done in order to protect as much as possible the data. The protection is intended in the sense:

a) control of who is downloading the data via a password generated on-line and communicated via e_mail to the requester;
b) avoid a direct access to the data but requesting a specific authorization that is recorded in the database;
c) avoid to store the data in the web space but only a copy of them.

Other types of protections are present but are not fully described here in order to avoid making them publicly known. Basically it may happen that the web site is attached but the data must be preserved.

There is a common consensus that the Microsoft Internet Information Server does not give enough guarantee of security. As a consequence of this some companies do not have Windows-based Internet sites. They use Windows only in Intranet applications. A possible solution is the adoption of Apache Internet Server and Chilisoft! Software to simulate ASP pages. This is the solution used also at JRC.

4.10 Description of the STRESA training week

The CERTA participants have attended a small training program at JRC Ispra which had the objective to instruct them to setup and use the STRESA database, to convert the experimental data in the WinGraf format and to create and modify the specific web pages of their STRESA web site.

The program of the STRESA training week was the following:

DAY 1

1. Introduction to STRESA database
2. Setup of STRESA database
3. Operations on the database
    a. Internet function
    b. Access Function

DAY 2

4. Data Conversion
5. Elaboration of files (Points Reduction, Zero Time Change, Common times)
6. Creation of WinGraf and ASCII data files

DAY

7. Modification of the web files
8. Customization of figures
9. Creation of Test Outline Pages

DAY

10. Repetition of STRESA installation

DAY 5 - (optional

11. Any other business

As the participant arrived at JRC Ispra they were finding a computer equipped only with:

- Microsoft NT 4.0 Operating System
- Microsoft Access
- Microsoft Personal Web Server (a simplified version of the Internet Information Server)

It was possible at any time to restart from the initial clean state if a new attempt of the installation was necessary. This was possible with an image of the system at the beginning.

After an initial description of the characteristics of the database and the description of all the tables present in the Access database (about half day), a first setup of the STRESA database was shown. The participants received an initial CD rom which contained all the various parts of the database including their respective specific installation which was prepared before they came at JRC Ispra.

The setup of the STRESA database proceeded according to the Setup procedure described in the STRESA users manual and reported in Appendix A of this report for easy consultation. Once demonstrated the setup procedure the first time, the system was re-initialized and the training person alone reinstalled a second time. If necessary we were ready to give support.

The second day was dedicated to the conversion of the data from the original format into the specific WinGraf format in order to be ready for introduction in the STRESA database. In order to do this one conversion program for each participant was written and are reported in Appendices. The basic structure of these programs is:

1) Reading the original data
2) Storing the data in vectors
3) Writing the vectores in the WinGraf Format

The part different was the number 1) while 2 and 3 where identical for all the programs.

At the end of the second day it was possible to create the data files that would go into the database. In some cases meantime we have also scanned original documents and also the pdf files of the data reports where therefore available to be introduced in the database.

During the second day we also have given a small training in the use of the most common functions of the WinGraf programme, which was distributed to the participants together with the STRESA database.

The third day was dedicated to the modification of the web files, to show what is possible to modify and adapt to its own web structures and what cannot be modified. Then we created also the specific pages that describe the test facility and the outline of each of the two tests introduced in the database.

The fourth day was dedicated to copy of the whole material back on the CD roms, reinitialization of the computer and reinstallation from the beginning. This is done in order to be sure that when the user comes back and has to install the database on his server he is able to perform this operation without any problem.

The last day is optional and most often we have not used unless there was something still unclear that needed more attention. It was decided to perform the training week singularly to each participant in order to be sure that all were receiving the maximum support and information and could have a direct and continous link with us.

As a result the following 8 training weeks were organized in the period January to October 2001:

ORGANIZATION	Trainee	Date of Training (start date)
SIET	S. Gandolfi	29.01.01
KFKI	A. Guba	26.02.01
FRAMATOME ANP	B. Schoen	21.05.01
STUDSVIK	L. Nilsson	11.06.01
PISA	A. Piagentini	09.07.01
CEA	D. Dumont	10.09.01
LTKK	V. Riikonen	24.09.01
PSI	Luebbesmeier	15.10.01

The result of the training weeks should be the creation in-house of the STRESA nodes. However not all the participants have set-up the STRESA nodes immediately. Some of them have done it as coming back from the training. For them it was easy to perform the set-up since most of the concepts were still fresh. Some of the groups waited and some did not set-up the web sites.

The reasons for not-having set-up the web site is that in some cases it was considered a risky web site even if put outside corporate Internet network or outrside firewalls (as it is in the case of JRC).

4.11 Experience of CERTA members in the installation of the STRESA databases

4.11.1 JRC

JRC developed STRESA database therefore its experience is not as relevant as for the other participants. The web server is:

http://asa2.jrc.it/stresa

and contains data coming from LOBI, FARO and KROTOS test facilities. The server is a 4x800 MHz processor Windows 2000 server. The Internet server is Apache with ChiliASP! Software to simulate ASP pages.

Since the start of the STRESA experience several requests regarding FARO and KROTOS and some for LOBI have been received and processed on-line. In the past a request of experimental data took some hours to find the right files or tape, prepare the envelope, the accompaining letter and perform the mail. Now it is a question of seconds. Great advantage also from the point of view of the user which receive the material within minutes instead of weeks.

4.11.2 SIET

Results of the training

During the last week of January 2001 SIET personnel was instructed in the installation of the STRESA_SIET database on a server, in the filling with text/images and in the management of the access by the users.

Such training allowed SIET personnel to learn the basic use of commercial software as:

- Microsoft Visual Studio;
- Microsoft Access;
- Microsoft operative system NT server.

Moreover specific tools (software programs) for WEB site development and for the internet/intranet working area were used. At the end of such training week the copy of the SIET_STRESA database was released to SIET to be installed on the home server.

Installation in the home servers

The STRESA_SIET database is now installed at ENEA-Bologna and it is reachable at the following URL:

http://arancia.arcoveggio.enea.it/stresa_siet (NT 4 Server).

Running the STRESA database

The STRESA_SIET database server is located far-away from SIET area, in some cases this might cause a possible delay in the updating of database and in the releasing of access authorization.

4.11.3 KFKI

KFKI installed the web server at the following address:

http://guba.aeki.kfki.hu/stresa_aeki

The web server is a 600 MHz Pentium III computer, equipped with NT Server.

During the one week training period building of the STRESA database of the PMK-2 facility is made successfully on the JRC server at Ispra. Beforehand, the available documentation of the selected two experiments was collected. These were the printouts of the experimental data reports, the measured data sets in electronic format and a general description of the facility.

As the first step in the training period, the structure of the already existing STRESA databases was shown. The differentiating in the user rights are very straight and logical, covering all the possible needs of handling and distributing the experimental data. Then the informatics infrastructure was examined, which programs are used, how this structure is created, how can it be managed. Although I did not have strong background in this field, it was rather easy to follow the STRESA manual. This training period was successful, all the knowledge was given which is enough to run and maintain the STRESA database.

The installation begun after the training period, due to some difficulties it took longer time than expected but finally succeeded. The STRESA system was installed on a PC that is used for making mostly thermohydraulic analysis, with only some basic programs installed. Therefore the necessary programs for STRESA had to be installed, such as the Microsoft Web Server, the Microsoft Office, Microsoft Visual Studio, WebGraf, etc. After the right version of all the programs were in the computer, there was no problem populating the available database to the home server.

Since the STRESA database is installed in the home server it is working properly.

4.11.4 FRAMATOME ANP

Prior to the training week examples of data were sent to JRC in order to correctly setup the reading programme for the PKL and UPTF data structure. With this preparation the PKL and UPTF data could be handled without any problems.

During the training week first the structure and the handling of the STRESA database was described and then the test report and the data of 2 PKL and UPTF tests each were ienstalled. The installation stored on CD-ROM for the realization of the STRESA database at FRAMATOME ANP was provided. The training week at Ispra was very useful to get an overview how to install and to operate the STRESA database.

After the training week the STRESA database was installed on a computer within the FRAMATOME ANP intranet (Windows NT4.0 Workstation using option pack). After further consultation with JRC (by phone) concerning the start of the application the installation could easily be completed. Not all features of the database were tested. The access to the STRESA database from the Internet has currently not been realized because:

- The installation of a WEB application within the FRAMATOME ANP Intranet which is
accessible from the Internet is not feasible due to company regulations,

- The installation of an application based on Windows (like the STRESA database) cannot be realized on a FRAMATOME ANP internet or extranet server (designated for such applications) since these servers are based on LINUX.

Alternative solutions to realize the internet access are going to be discussed. Remark: First attempts at JRC to install STRESA on a LINUX server showed the principle feasibility. But it also made clear that the conversion would be very time intensive.

Currently the STRESA database is installed on a computer within the FRAMATOME ANP intranet and is running properly. As operating system Windows NT4.0 Workstation using the option pack is applied.

4.11.5 STUDSVIK

The web server had been maintained in October 2001 at the address http://193.125.78.104/stresa_studsvik

In June 2001 Lars Nilsson had participated in CERTA training with the data and documents collected for the FIX-II experimental facility. STRESA_STUDSVIK software and data base (STRESA software and data base related to FIX-II facility) had been prepared during the training.

It was not possible to install the software and data on anyone of the computers of Studsvik's network because users are not able to reach this network from Internet. According to this it was decided to install data and software on the server of one of private companies providing web services. After the checking it was recognised that it is not possible to use "web-hotel" (the server of web service company shared with other users) because STRESA software is using ActiveX components which need to be installed in the system directory of the server.
The STRESA_STUDSVIK software and data base had been installed on the dedicated server of the company CBR Soft Pte Ltd. The installation of the STRESA software had been made by D.Hofman (Studsvik Eco & Safety AB) and specialists from the CBR Soft Pte Ltd. L.Papush and A. Zaslavsky. The password-protected FTP access to the server had been established to support remote updates during the server maintenance and testing period.

The operating system of the server is Windows 2000[2].

After the installation of software it was necessary to give correct read/execute permission for some of the files.The installation of updated version of Stresa component and corresponding .asp files was performed to provide correct functionality related to data base browsing and to introduce possibility to add short text-based information for the data base documents. After these changes the STRESA_STUDSVIK server is working properly and reliable. Some changes in site external layout in comparison with the version made during the CERTA training week had been carried out. In particular direct link to CERTA network portal had been included into "menu" frame after demonstration of the site to the potential users.

4.11.6 PISA University

Initially it was decided to use a standard PC with Windows Me Operating System to perform the server operations. It was noticed however that the set-up of the anti-virus program was on

1.1.1.1

[2] It was noticed that during the installation of Stresa and Webgraf components on Windows 2000 persisting requests for the reboot had been issued. After the several reboots the problem was solved by deleting of the names of the files already installed on the system (for example libraries supporting OLE automation and Visual Basic run-time library) from the <bootstrap files> section of the corresponding setup.lst files. This problem was not general for all Windows 2000 installations.

that computer was conflicting with the requests of the web services after one access to the server itself.

Therefore it was decided to install the web service on a dedicated PC equipped with Windows NT 4.0 Service Pack 3. In order to successfully accomplish the installation of the web service the Service Pack has been upgraded to version 5. Microsoft Visual Studio 5 was already present on this computer.

Some new libraries sent by Ispra have also been installed substituting those made available during the training week in Ispra. The help of of the JRC staff to successfully accomplish the work must be acknowledged.

4.11.7 CEA

The CEA reprresentative attended the training week in Ispra and implemented the BETHSY web-site on the JRC server. It apperas that due to CEA internal regulations no clearance has been provided as yet for the installation of the BETSHSY database on their home server. Regarding their experience, no specific comments have been provided by CEA.

4.11.8 LTKK-VTT

The training session at Ispra was very useful. It gave a good overview of the STRESA database and how it works. The session took three days, so there was time to test the database under Apache Web server using Chili!Soft support for ASP pages. That experience made it easy to make a decision to use Apache Web Server in LTKK home server instead of Microsoft Internet Information Server (IIS).

It was decided to replace one of the old Windows NT based servers for STRESA database. Before that the installation of the database was tested on Windows NT server using IIS. After updating the Microsoft Universal Data Access (MDAC) components the database was running. All features of the database were not tested.

The final installation was donein on a new Windows 2000 server using Apache Web server and Chili!Soft ASP. The Apache version was newer than the one used at Ispra. The Chili!Soft ASP installation did not recognise the new version of the Apache without some tricks.

Implementation of the database in Windows 2000 environment was quite easy. There were only few problems. We were using Microsoft Access 2000 but the STRESA database initially did not support it. Sending email did not work because of a problem in Jmail installation and some conflicts with lower and upper case letters in the definition file (setappl.asp).

When the database was running we found that logging out of the database did not work every time. The problem was in caching. WinGraf had also a bug that left the process running in Windows 2000 environment. Now when the small problems are solved the database is running fine and the server seems to be very fast and efficient.

4.11.9 PSI

The four days of training consisted of three parts, namely a basic description of the STRESA logic and how it has to be set up on the home server, the installation of the specific PSI data (ISP-42) on the JRC-STRESA server and a final attempt of the participant to set up the system on a stand-alone PC.

ISP-42 database has been installed successfully on the JRC server except for one of the six phases of the experiment, where the PSI- data was incomplete. Since most of the documentation was prepared beforehand by JRC (A. Annunziato), the remaining task was the conversion of the data to the STRESA- format, its installation and the writing of some additional documentation.

An image of the final PSI partition of STRESA was then copied to a CD-ROM. Finally, the trainee had to install this PSI-partition of STRESA on a stand-alone PC.

A dedicated PC (600 MHz Pentium III) is already available. Due to the general security measures at PSI and also PSI Internet web site is based on UNIX, it has not been possible to install STRESA on the dedicated PC. Solution is sought, presently. Consequently, installation in the home server has not been yet done.

Not yet done, it depends on the solution, which will be obtained in relation to Internet security measures at PSI.

4.12 Final configuration of the CERTA network

The final configuration of the CERTA database is the following:

CERTA	The portal, from this you can navigate into the whole CERTA space	- Contains the data related to the CERTA Activity	http://asa2.jrc.it/certa
STRESA_CEA	BETHSY facility	- 6.9c Loss of RHR at midloop operation, pressuriser and SG outlet plenum manways open - 9.1b Cold Leg Break without HPIS and delayed application of an ultimate procedure	http://asa2.jrc.it/stresa_cea
STRESA_STUDVIK	FIX-II facility	- 2032 RC pump coast down simulation for internal RCP BWR with low pump inertia - 3061 100% bre ak in circulation line - 5052 200% break in circulation line - 6261 MSIV closure	http://193.125.78.104/stresa_studsvik
STRESA	LOBI facility	- All the 70 LOBI tests	http://asa2.jrc.it/stresa
STRESA_LTKK	PACTEL	- ISP-33 Stepwise inventory reduction - LOF-10 Loss-of-feedwater	http://ydin.win.lut.fi/stresa_ltkk
STRESA_PSI	PANDA	- ISP-42 International Standard Problem 42 (6 phases, only 5 included till now)	http://asa2.jrc.it/stresa_psi
STRESA_PISA	PIPERONE	- PO-IC-2 Phases A/II and B - Isolation Condenser (IC) phenomena - PO-SB-7 Small Break LOCA (2.6%) in the recirculation line ISP21. Core uncovery.	http://131.114.29.71/stresa_pisa
STRESA_FRAMATOME_ANP	PKL UPTF	PKL -III A2.1 Cooldown procedure with 4SGs under loss of off-site power conditions -III B3.3 Reflux Condenser CCFL Test UPTF -Test 10B-run081 Steam/water flow phenomena at the upper tie plate -Test 5A-run063 Steam/water flow phenomena in the intact cold legs	http://asa2.jrc.it/stresa_FRAMATOME_ANP
STRESA_FRAMATOME_ANP	PKL UPTF	PKL - III A2.1 Station Blackout CPT LOBI A1-87 - III B3.3 Reflux Condenser CCFL Test UPTF - Test 10B-run081 Steam/water flow phenomena at the upper tie plate - Test 5A-run063 Steam/water flow phenomena in the intact cold legs	http://asa2.jrc.it/stresa_FRAMATOME_ANP
STRESA_AEKI	PMK	- CLB14 7,4% CLB LOCA with Secondary B&F (SPE4) - PRISE2 SG Collector Cover Lift Up (SPE3)	http://guba.aeki.kfki.hu/stresa_aeki
STRESA_SIET	SPES	- SPFW02 Loss of feed-water with bleed and feed - SPSB03 SBLOCA 6" with decay power, Counterpart Test program among SPES-LOBI-BETHSY-LSTF	http://arancia.arcoveggio.enea.it/stresa_siet

The main CERTA portal appear as in Fig. 41 showing all the facilities which are part of the netwok. There are two columns: one on the left that is the controlled area (i.e. a user/password is to be supplied to enter), one completely free that can be accessed by any user.

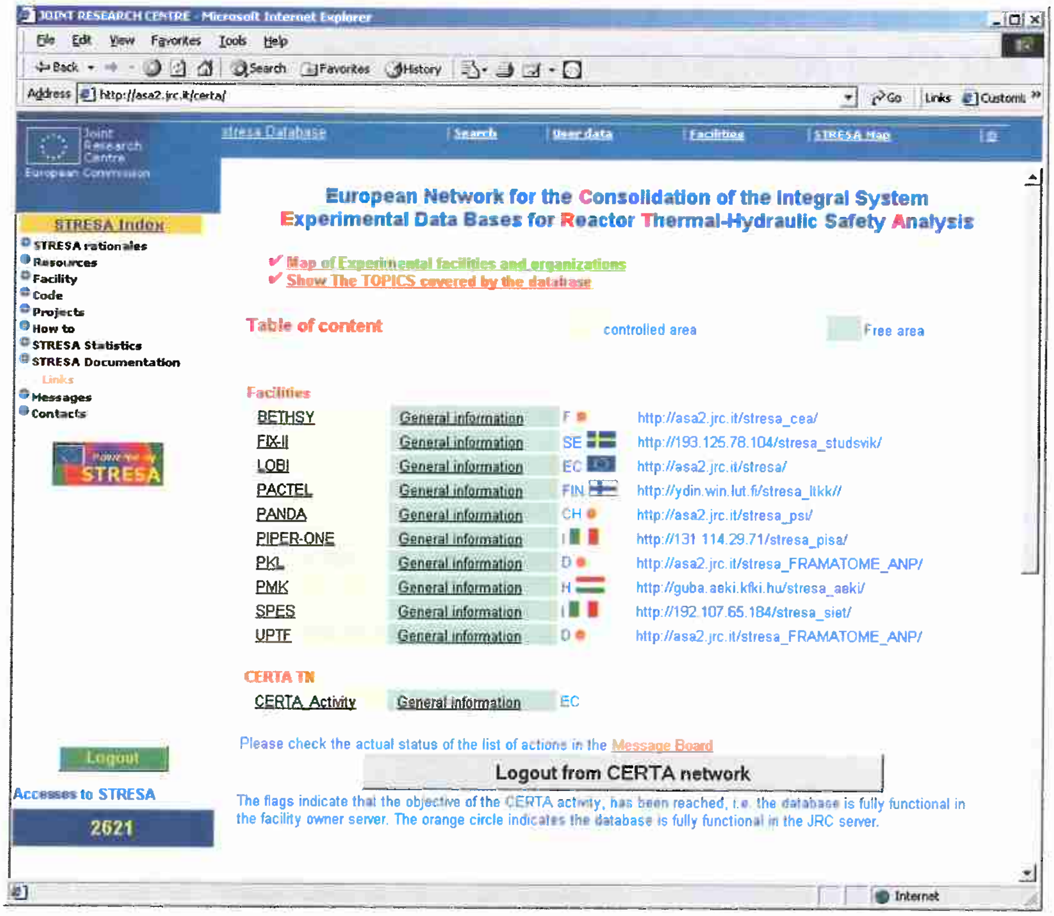


Fig. 41 – Main portal of CERTA network

Clicking the **General Information** it is possible to get a facility description. Clicking a facility it is possible to get the list of experiments for any facility and here also an outline page for each experiment.

The Facility description can be visualized by anybody even without entering in the database while all the registered users even not having a specific authorization for any document may see the outline page. In the following figures example of facility and tests outline pages are presented.

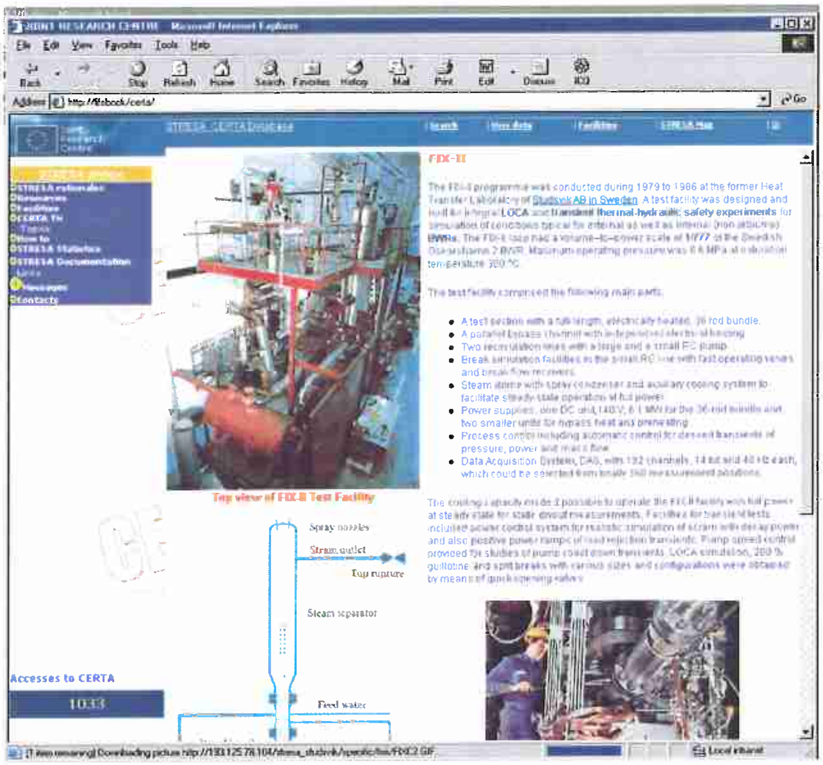


Fig. 42 – Example of Facility description page (FIX-II)

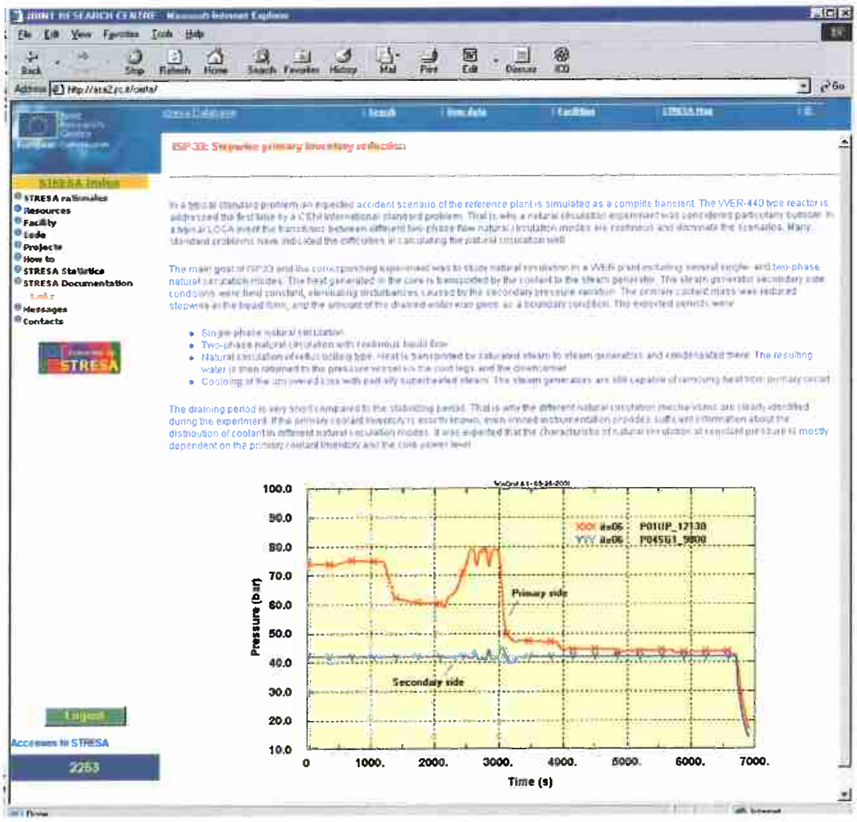


Fig. 43 – Example of test outline page (Test ISP-33 Pactel)

A useful feature of the CERTA network is the search by topics. It is possible to display a list of phenomena topics under which included tests have been classified. This list (Fig. 44) indicates also the number of tests falling under that category.

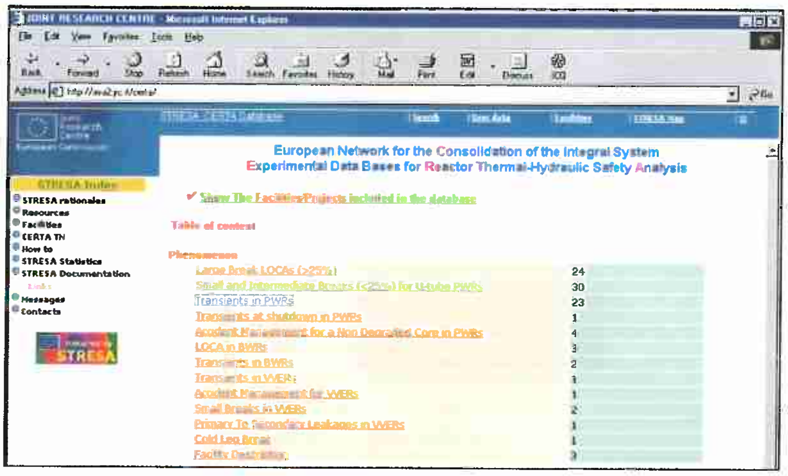


Fig. 44 - List of phenomena topics

Therefore if one wants to see which are the tests of a certain category, i.e. Transients in PWRs, the list of tests in Fig. 45 is obtained and it is then possible to choose a particular test.

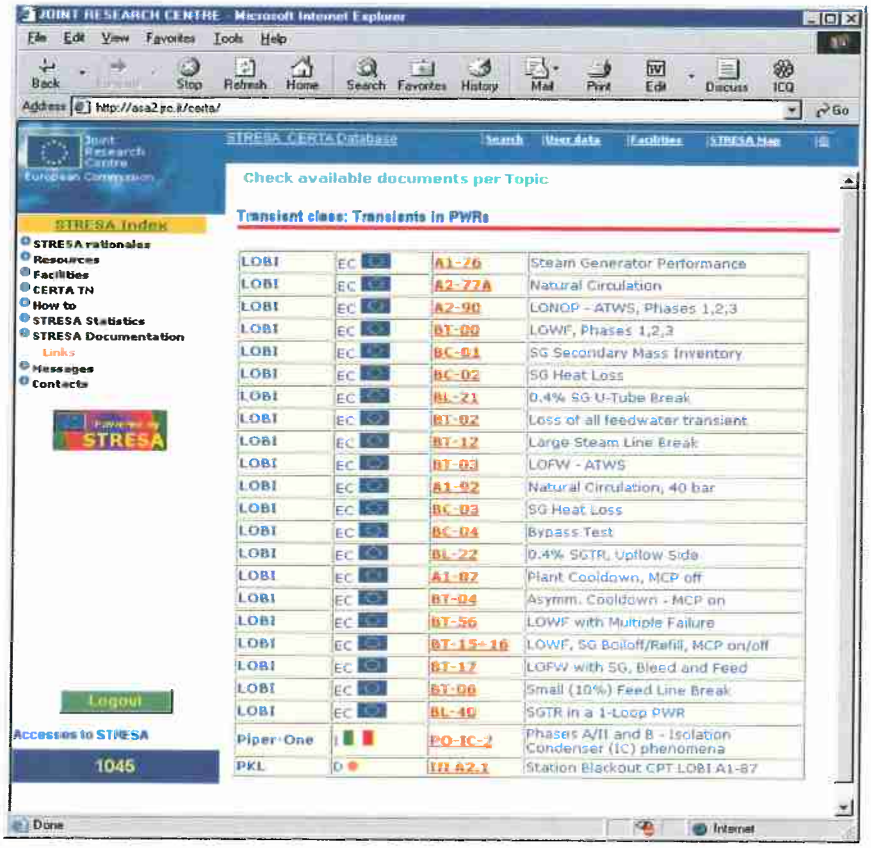


Fig. 45 - List of tests related to "Transients in PWR" topic

The list of phenomena may be configured and may be extended to include additional phenomena defined by the user.

Another useful feature of the CERTA network is the possibility to search at the same time in all the servers connected a determined word(s). All the servers are interrogated and give as answer the occurrence of the requested word. For instance if all the servers were isolated, the search had to be manually repeated on each server after logged in.

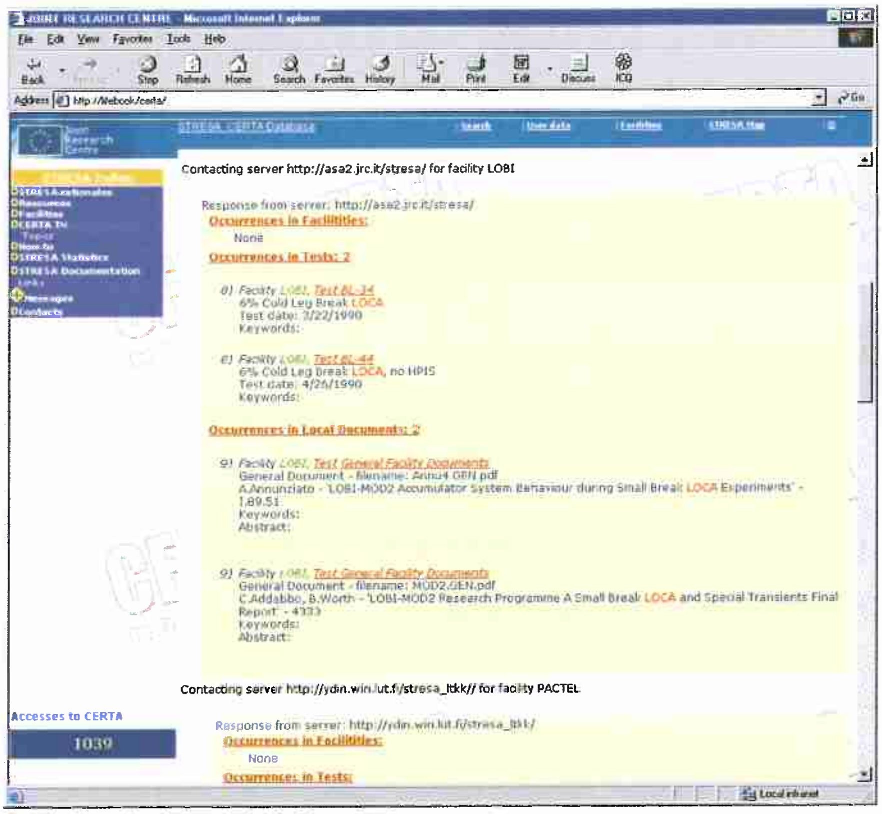


Fig. 46 – Response from some of the servers to the search request for **LOCA** word

4.13 Perspectives on the CERTA Thematic Networ

As it was configured the CERTA network is now operative and working. This means that all the web sites are operative, the links are working, the databases are, although limited in extension, complete. There are however a number of issues that must be clear in order to assure a proper future behaviour of the network itself.

4.13.1 Introduction of new tests

If a new test is included in a local database, it is necessary, if it is intended to show it also in the CERTA network that the responsible of the local database communicates the name of the test and the description of the test to the CERTA responsible. Also the topics related to the new test should be communicated in order to find the test when the topics are displayed.

4.13.2 Change of test names

It is better to avoid, if possible, the change of the test name. If necessary however this may be done and it is necessary in this case to change:

- in the local databases all the test names in the Documents table and Authorization table.
- In the CERTA portal the name of the test in the Tests table.

4.13.3 Introduction of new documents

If new documents are included related to a determined test it is not necessary any communication to the CERTA responsible.

4.13.4 Connection with other STRESA nodes

In case it is necessary to include a local node in another STRESA network, while keeping the connection with the CERTA, it is necessary to add in the Networks table the new network and which facilities are connected with that network. Then also in the Tests and Documents table updates the Networks Allowed field including the new network.

4.13.5 Response to requests of users

As a general rule the responsible of the local database should answer timely to the requests of the users, which come to him via e_mail. If he is not present for a long period he should replace his e_mail in the database (*Facility* table, *e-mail of responsible* field) with the name of a person who can respond.

4.13.6 Global Check of the CERTA network

From time to time a check will be performed to see if all the links are correctly specified and there are not missed links. If there are they are communicated to the local responsible. Since it is possible to perform this check also locally it is a good practice to check if its own web site has or not any missed link with the dedicated command in the STRESA site.

4.14 Remarks on the CERTA Network Database

The CERTA network has been successfully set-up. It was possible to demonstrate that a distributed network is possible and that very useful information can be stored and retrieved in a very user-friendly mode.

It was also demonstrated that the CERTA network, as it is, can be easily operated and that guarantees that the data owner can track their users and control any operation on the database.

The installation of the network was performed by mean of dedicated short Training periods in which the STRESA web masters have learnt how to set-up the database and how to convert their existing data.

The greatest benefit of such a network arrangement is in the possibility to perform search by topic or by word over the whole network and this is particularly important when many servers are connected together to form a complex knowledge base system.

The CERTA web site is

http://asa2.jrc.it/certa

5 General Conclusions

A comprehensive experimental database has been acquired in European integral test facilities during the last three-decades to support the thermal-hydraulic safety analysis of water cooled reactors (i.e., PWR, BWR and VVER) and the development/assessment of related analytical methodologies. The acquisition of these data consisting of c. 1000 integral system experiments has involved a considerable financial commitment from both institutional and industrial reactor safety research organisations which has been estimated in the order of 450 Million EUROs.

To date, some of the experimental programmes subject matter of the CERTA Thematic Network have been terminated and several test facilities have been dismantled; e.g., LOBI, BETHSY, UPTF and FIX-II. Some of the test facilities are still in operation such as PKL, PACTEL, PMK and PANDA; SPES and PIPERONE are maintained in stand-by conditions.

The acquired integral system effect test databases are currently maintained in a variety of support media and format. Some support media are not any more serviced by adequate hardware/software and some data are available only on paper format. The extent to which supporting documentation (e.g., test data analysis reports, test facility design drawing, test facility description and information on instrumentation system, etc.) is maintained is in some cases questionable. Often they are strictly dependent on individuals' expertise and know-how/know-where which for obvious reasons will be in time progressively diluted.

It is generally recognised that the subject experimental databases represent a unique set of reference information relevant to accident and transient analysis of current water cooled reactors. Due to current and even prospected financial constraints which can prohibit revisiting such large scale experimental programmes, it is felt that it is an obligation of the nuclear community to ensure their preservation and user-friendly access/retrieve capabilities using modern information technologies.

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6 APPENDIX A - The STRESA setup procedure.

The complete setup procedure can be summarized in the following steps:

Setup steps for the STRESA Database

In this document xxx represent the particular database name. As an example for the STRESA version for Forshugszentrum Karlsruhe, xxx is fzk, and you have to substitute all occurrences of xxx with fzk.

1. Copy all the directories from the CD rom to a temporary folder on the hard disk and remove the read-only flags on all the files
2. Locate the directory **stresaClass** in the **Common Files** folder in the temporary directory you created in step 1 and select it
3. Launch the program **setup.** This will install the stresadll.dll If requested reboot the computer and repeat step 2.
4. Locate the directory **wgClass** in the **Common Files** folder in the temporary directory you created in step 2 and select it
5. Launch the program **setup.** This will install the webgraf.dll
6. Locate the directory **jmail** in the **Common Files** folder and select it
7. Launch the program **wjmail3.exe**[3]
8. Locate the directory **metaview** in the **Common Files** folder and select it
9. Copy the file **metagif32.dll** in winnt/system32 directory
10. Locate the directory **AspUpload** in the **Common Files** folder and select it
11. Change directory to **AspSmartUpload**
12. Copy the files **aspSmartUploadUtil.dll and AspSmartUpload.dll** in the **\winnt\system32** directory [4]
13. Register the **aspSmartUpload.dll** library running the command:
14. *regsvr32* \winnt\system32**aspSmartUpload.dll**[5]
15. This command is given pressing Start->Run and typing the command in. If everything was correct you should see the following message: DllRegisterServer... succeded.
16. Locate the directory **stresa_xxx** in the *XXX files* subdirectory in the temporary setup folder.
17. Locate the web directory on your server. In general this directory is ***c:\inetPub\wwwRoot*** but it may be different on your computer.
18. Create a directory **stresa_xxx** and copy here the content of the similar directory in the temporary setup folder
19. Locate the directory **xxx_dbase** in the *XXX files* subdirectory in the distribution cd rom.
20. Create a similar directory on your server, i.e. in disk c:\ and copy here the whole content of **xxx_dbase**
21. Use the Personal Web Server or IIS 5.0 Internet Service Manager to create a virtual directory that you will call stresa_xxx which is connected with directory stresa_xxx and give it write permissions (*sometimes this step can be skipped*).
22. Locate the file **setappl.asp** which is located in the directory **stresa_xxx\scripts\vb** of the web site (probably under inetPub\wwwRoot**stresa_xxx\scripts\vb**
23. Edit the file setappl.asp to respect the following items:
    Drive = "c:\xxx_dbase\"

1.1.1.1

[3] To setup jmail you should use jmail.exe instead of w3setup.exe if you use temporary folder. w3setup installs the program to be used from the setup folder. If you remove the temporary setup folder the jmail can not work. jmail.exe will install the software into the user defined folder and you can remove the temporary setup folder.

[4] Sometimes the folders options prevents to view all the files, hiding system files. If you do not see the .dll files, select My Computer on the desktop, select View-Folder Options, click on view tab. The Show all files radio button has to be activated and the Hide file extension check box has to be unselected.

[5] Since a blank may be present in the directory name (i.e: ...\Common Files\...), you have to enclose the whole dll name between double apices ".

this line must indicate the absolute path where you have copied the database (see point 18)

Application("pathDB") = "c:\xxx_dbase\"

Application("DB_server")="stresa_xxx"

same as above point a

Application("pathASP") = "c:\InetPub\wwwroot\stresa_xxx\"

this line must indicate the absolute location of the web files. If your web site is not ic c:\InetPub… change it accordingly.

application("mail_server_IP")="139.191.8.246:25"

this line indicates the local mail server. Change it to reflect your own mail server IP address and port (25).

application("mail_sender")= "alessandro.annunziato@jrc.it"

this line indicates the name of a known user on the mail server, otherwise no mail can be delivered.

application("mail_copyto")= alessandro.annunziato@jrc.it

this line indicates the name of a user you want to notify when a new user register in the STRESA database.

session ("check_e_mail")= True [or False]

if you write True, each time a user tries to enter the database with a wrong userid or password a notification is sent to the e_mail address indicated in point f.

24. Now you are ready to go on-line with http://your_server/stresa_xxx

7 APPENDIX B – STRESA Conversion Programmes

7.1 SPES Conversion programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)

Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo, unit$)
Dim aa As String * 82
rec = irec

LSet cr$ = Chr$(10) + Chr$(13)
' scrivo prima riga
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = desc$
    Mid$(aa, 50, 13) = format1(vmin)
    Mid$(aa, 65, 13) = format1(vmax)
    Mid$(aa, 42, 6) = "WgD2.1"
    Mid$(aa, 80, 1) = LTrim(Str(itipo))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la seconda riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 9) = LTrim(Str$(np))
    Mid(aa, 60, 10) = unit$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la terza riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = descTime$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
```

```
End Function


Private Sub Command3_Click()
On Error GoTo hand
Close 1

ReDim xx(70000) As Single, yy(70000) As Single, timeVectors(50, 3)
Dim xmin As Single, xmax As Single
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True
file = Text2
If Dir(file) <> "" Then
    Kill file
End If

rawdata = True
npMaxToread = 4134
MsgBox ("Attenzione leggo solo i primi " & npMaxToread & " punti ")

Close 2: Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0
ndesc = 0

Open Text1 For Input As #1

iflag = False

2   Line Input #1, A$

ndesc = ndesc + 1

desc$ = Trim(Mid(LTrim(A$), 1, 8))
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, " ", "_", 1, -1)

unit$ = Trim(Mid(LTrim(A$), 29, 8))
If iflag = True Then
    valido$ = Right(A$, 2)
Else
    iflag = True
End If

' solo per raw data
If rawdata = True And InStr(desc$, "TIME") = 0 Then
    desc$ = desc$ + "_" + unit$
End If


If InStr(A$, "TIME") <> 0 Then
    timeVector = True
    npunti0 = Val(Mid(A$, 9, 4))
Else
    timeVector = False
End If



Debug.Print npunti

desct$ = "time001"

npu = 0
ymin = 1E+30: ymax = -1E+30
Debug.Print desc$, tmin, freq, desct$
DoEvents
For k = 1 To npunti0
    Line Input #1, A$

        If k <= npMaxToread Then
```

```
            npu = npu + 1
            dd = Val(A$)
            yy(npu) = dd
            If yy(npu) > ymax Then ymax = yy(npu)
            If yy(npu) < ymin Then ymin = yy(npu)
            If npu + 1 > npunti0 Then GoTo 1
        End If
Next k
1  If timeVector = True Then

       npunti = npu
   End If

   If rawdata = True Or valido$ <> " 0" Then
        Text3 = desc$ & " " & tmin & " " & freq
        If timeVector = True Then
            ir = "R"
            itipo = 1
            desc$ = desct$

        Else
            ir = ""
            itipo = 2
        End If
        rec0 = rec0 + 1
        Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npunti, itipo,
unit$)
        CwriteData file, rec0, yy(0), ymin, ymax, npunti, ir


   End If
   GoTo 2

11 Close 1

Close 2
MsgBox ("Conversion completed")
Exit Sub



hand:
If Erl = 10 Then Resume 11
If Erl = 20 Then Resume 11
If Err = 62 Then Resume 11
Stop
Resume Next

End Sub

Private Sub Text1_DblClick()
CommonDialog1.FileName = ".txt"

CommonDialog1.Action = 1
Text1 = CommonDialog1.FileName
End Sub


Private Sub Text2_DblClick()
CommonDialog1.FileName = "*.dat"


CommonDialog1.Action = 1
Text2 = CommonDialog1.FileName

End Sub
```

7.2 CEA Conversion programme

```
Private Declare Sub CwriteDataR Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Double, ymin As Double, ymax As Double, ByVal nump As Long, ByVal itipo As String)
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)
Private Sub Command1_Click()
On Error GoTo hand
Close 1

' Lettura dati BETHSY

ReDim xx(70000) As Double, yy(70000) As Single, timeVectors(100, 3)
Dim xmin As Double, xmax As Double
Dim ymin As Single, ymax As Single
Dim aa As String * 82

ntv = 0
file = Text2 '"c:\loft_125.dat"
If Dir(file) <> "" Then
    Kill file
End If
Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0
ndesc = 0
Close 3

f$ = Text1
Close 1
Open f$ For Input As #1


2 Line Input #1, A$
  desc$ = Trim(A$)
  Text3 = desc$
  ' reads 5 lines
  For k = 1 To 5: Line Input #1, A$: Next
    '12345678901234567890
    'BETHSY  TEMPS        7584
    npunti = Val(Mid(A$, 20, 7))

    ndesc = ndesc + 1
    npu = 0
    ymin = 1E+30: ymax = -1E+30: xmin = 1E+30: xmax = -1E+30


    For k = 1 To npunti
        Input #1, t, v
        npu = npu + 1
        xx(npu) = t
        If xx(npu) > xmax Then xmax = xx(npu)
        If xx(npu) < xmin Then xmin = xx(npu)
        yy(npu) = v
        If yy(npu) > ymax Then ymax = yy(npu)
        If yy(npu) < ymin Then ymin = yy(npu)
    Next k

    ' tries to understand if this timevector was already defined or not.
    timevector = True
    For k = 1 To ntv
        If timeVectors(k, 1) = xmin And timeVectors(k, 2) = xmax And timeVectors(k, 3)
= npunti Then
            timevector = False
            desct$ = "time_" & k
        End If
    Next
    If timevector = True Then
        ntv = ntv + 1
        timeVectors(ntv, 1) = xmin
        timeVectors(ntv, 2) = xmax
        timeVectors(ntv, 3) = npunti
        desct$ = "time_" & ntv
    End If
1     GoSub scrivi
      Line Input #1, A$
```

```
        GoTo 2

11 Close 1
Close 3
Close 2
MsgBox ("Conversion completed")
Exit Sub

scrivi:
DoEvents

If timevector = True Then
    ir = "R"
    itipo = 1
    npunti0 = npunti
    rec0 = rec0 + 1
    Call ScriviTestaFormato2(2, rec0, desct$, desct$, xmin, xmax, npunti, itipo)
    CwriteDataR file, rec0, xx(0), xmin, xmax, npunti, ir
End If

ir = ""
itipo = 2
rec0 = rec0 + 1
Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npunti, itipo)
CwriteData file, rec0, yy(0), ymin, ymax, npunti, ir
Return

hand:
If Erl = 10 Then Resume 11
If Erl = 20 Then Resume 11
If Err = 62 Then Resume 11
Stop
Resume Next
End Sub


Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo)
Dim aa As String * 82
rec = irec

LSet cr$ = Chr$(10) + Chr$(13)
' scrivo prima riga
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = desc$
    Mid$(aa, 50, 13) = format1(vmin)
    Mid$(aa, 65, 13) = format1(vmax)
    Mid$(aa, 42, 6) = "WgD2.1"
    Mid$(aa, 80, 1) = LTrim(Str(itipo))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la seconda riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 9) = LTrim(Str$(np))
    aa = Mid$(aa, 1, 80) + cr$
```

```
    Put nf, irec, aa

' scrivo la terza riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = descTime$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
End Function


Private Sub Form_Load()

End Sub

Private Sub Text1_DblClick()
CommonDialog1.FileName = ".txt"

CommonDialog1.Action = 1
Text1 = CommonDialog1.FileName
End Sub


Private Sub Text2_DblClick()
CommonDialog1.FileName = "*.dat"


CommonDialog1.Action = 1
Text2 = CommonDialog1.FileName

End Sub
```

7.3 FIX Conversion programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)

Private Sub Command1_Click()
On Error GoTo hand
Close 1

' Lettura dati FIX

ReDim xx(70000) As Single, yy(70000) As Single, timeVectors(100, 3)
Dim xmin As Single, xmax As Single
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True: ntv = 0
file = Text2 '"c:\loft_125.dat"
If Dir(file) <> "" Then
    Kill file
End If
Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0

ndesc = 0
Close 3
Open Text1 For Input As #3
While Not EOF(3)
    Line Input #3, f$

    GoSub leggifile
Wend
Close 3
Close 2
MsgBox ("Conversion completed")
Exit Sub

leggifile:
Form1.Cls
Mid(f$, 1, 2) = Drive1.Drive
Form1.Print f$
Form1.Print "------------------------------------------"
Close 1
Open f$ For Input As #1



2 Line Input #1, A$
If InStr(A$, "EXPERIMENT") <> 0 Then
   GoTo 2
End If
If InStr(A$, "TIME") <> 0 Then
    timevector = True
Else
    timevector = False
End If
ndesc = ndesc + 1
 '1224    86TIME
'12345678901
desc$ = Mid(A$, 11, Len(A$) - 11 + 1)
If InStr(desc$, "(") <> 0 Then
    n = InStr(desc$, "(")
    desc$ = RTrim(Mid(desc$, 1, n - 1))
End If
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, "  ", " ", 1, -1)
desc$ = Replace(desc$, " ", "_", 1, -1)
If InStr(A$, "TIME") = 0 Then
    primo = False
    pointer = True
    timevector = False
Else
    pointer = False
```

```
 End If
 tmin = Val(Mid(A$, 51, 15))
 freq = Val(Mid(A$, 66, 15))
 Text3 = desc$ & " " & tmin & " " & freq


 'Line Input #1, A$

 npunti = Val(Mid(A$, 1, 5))

 Debug.Print npunti
 If pointer = True Then
     If npunti <> npunti0 Then Stop
     GoTo 5
 End If
 If timevector = True Then GoTo 12
 For k = 1 To ntv

     If tmin = timeVectors(k, 1) And freq = timeVectors(k, 2) And npunti =
 timeVectors(k, 3) Then
         primo = False
         desct$ = "time" + Format(k, "000")
         GoTo 5
     End If
 Next k

 12 ntv = ntv + 1 ': If ntv = 58 Then Stop
 desct$ = "time" + Format(ntv, "000")
 'timeVectors(ntv, 1) = tmin: timeVectors(ntv, 2) = freq: timeVectors(ntv, 3) = npunti
 primo = True

 5 npu = 0
 ymin = 1E+30
 ymax = -1E+30
 Debug.Print desc$, tmin, freq, desct$
 For k = 1 To Int((npunti - 0.001) / 5) + 1
     Line Input #1, A$
 '    If A$ <> "  .000000000E+00  .000000000E+00  .000000000E+00  .000000000E+00
 .000000000E+00" Then Stop
  '   Debug.Print A$
     For j = 1 To 5
         npu = npu + 1
         If npu > npunti Then GoTo 1
         xx(npu) = tmin + (npu - 1) * freq
         dd = Mid(A$, (j - 1) * 16 + 1, 16)
         yy(npu) = Val(dd)
         If yy(npu) > ymax Then ymax = yy(npu)
         If yy(npu) < ymin Then ymin = yy(npu)

     Next j
 Next k
 1 xmin = tmin: xmax = tmin + (npunti - 1) * freq

   GoSub scrivi

 '  Do Until InStr(A$, "IDENTIFIER") <> 0
 '10    Line Input #1, A$
   'Loop
   GoTo 2

 11 Close 1

 Return

 scrivi:
 DoEvents

 If InStr(desc$, "TIME") <> 0 And timevector = False Then Stop
 If primo = True And timevector = False Then
     primo = False
     rec0 = rec0 + 1
     Call ScriviTestaFormato2(2, rec0, desct$, desct$, xmin, xmax, npunti, 1)
     CwriteData file, rec0, xx(0), xmin, xmax, npunti, "R"
 End If


 If timevector = True Then
```

```
    ir = "R"
    itipo = 1
    desc$ = desct$
    npunti0 = npunti
Else
    ir = ""
    itipo = 2
End If
rec0 = rec0 + 1
Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npunti, itipo)
CwriteData file, rec0, yy(0), ymin, ymax, npunti, ir
Return

hand:
If Erl = 10 Then Resume 11
If Erl = 20 Then Resume 11
If Err = 62 Then Resume 11
Stop
Resume Next
End Sub


Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function
```

7.4 PACTEL Conversion Programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)
Private Declare Sub CwriteDataR Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Double, ymin As Double, ymax As Double, ByVal nump As Long, ByVal itipo As String)

Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo, unit$)
Dim aa As String * 82
rec = irec

LSet cr$ = Chr$(10) + Chr$(13)
' scrivo prima riga
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = desc$
    Mid$(aa, 50, 13) = format1(vmin)
    Mid$(aa, 65, 13) = format1(vmax)
    Mid$(aa, 42, 6) = "WgD2.1"
    Mid$(aa, 80, 1) = LTrim(Str(itipo))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la seconda riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 9) = LTrim(Str$(np))
    Mid(aa, 60, 10) = unit$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la terza riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = descTime$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
End Function


Private Sub Command3_Click()
On Error GoTo hand
```

```
Close 1

ReDim xx(10000) As Double, yy(10000) As Single, timeVectors(50, 3), freqV(100),
npoints(100)
Dim xmin As Double, xmax As Double
Dim ymin As Single, ymax As Single
Dim descri(10), units(10), values(10, 10000)
Dim aa As String * 82

primo = True
file = Text2
If Dir(file) <> "" Then
    Kill file
End If

Close 2: Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0
ndesc = 0

desct$ = "Time"

For I = 0 To File1.ListCount - 1
    fi = Dir1.Path + "\" + File1.List(I)
    GoSub Read
Next
Close 2
MsgBox ("Conversion completed")

Exit Sub

''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Read:
Close 1: Open fi For Input As #1
While Trim(A$) <> "/"
    Line Input #1, A$
Wend

' reading loop starts
10 Line Input #1, A$
Line Input #1, b$
While InStr(A$, "  ") <> 0
    A$ = Replace(A$, "  ", " ")
Wend
While InStr(b$, "  ") <> 0
    b$ = Replace(b$, "  ", " ")
Wend

de = Split(Trim(A$), " ")
un = Split(Trim(b$), " ")
ndesc = UBound(de)
For k = 0 To ndesc
    descri(k) = de(k)
    units(k) = un(k)
Next
npu = 0
While EOF(1) = False And A$ <> ""
    Line Input #1, A$
    If Trim(A$) <> "" Then
        While InStr(A$, "  ") <> 0
            A$ = Replace(A$, "  ", " ")
        Wend
        va = Split(Trim(A$), " ")
        npu = npu + 1
        For k = 0 To ndesc
            values(k, npu) = Val(va(k))
        Next
    End If
Wend

' here i write the ndesc descriptors
For k = 1 To ndesc
    ymin = 1E+30: ymax = -1E+30
    xmin = 1E+30: xmax = -1E+30
    desc$ = descri(k)
    DoEvents
    For j = 1 To npu
```

```
            valuet = values(0, j)
            Valuey = values(k, j)
            yy(j) = Valuey
            xx(j) = valuet
            If yy(j) > ymax Then ymax = yy(j)
            If yy(j) < ymin Then ymin = yy(j)
            If xx(j) > xmax Then xmax = xx(j)
            If xx(j) < xmin Then xmin = xx(j)
        Next j
        found = False
        For j = 1 To ntimes
         ' note: here i assume that the time data points are equally spaced
            If timeVectors(j, 1) = xmin And timeVectors(j, 2) = xmax And timeVectors(j, 3)
 = npu Then
                found = True
                Exit For
            End If
        Next
        If found = False Then
            ntimes = ntimes + 1
            timeVectors(ntimes, 1) = xmin
            timeVectors(ntimes, 2) = xmax
            timeVectors(ntimes, 3) = npu
            desct$ = "Time_" & ntimes
            primo = True
        Else
            primo = False
        End If

        Text3 = desc & " " & ymin & " " & ymax
        If primo = True Then
            ir = "R"
            itipo = 1
            rec0 = rec0 + 1
            Call ScriviTestaFormato2(2, rec0, desct$, desct$, xmin, xmax, npu, itipo,
unit$)
            CwriteDataR file, rec0, xx(0), xmin, xmax, npu, ir
            primo = False
        End If
        itipo = 2
        ir = ""
        rec0 = rec0 + 1
        Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npu, itipo, unit$)
        CwriteData file, rec0, yy(0), ymin, ymax, npu, ir
1 Next k
If EOF(1) = False Then GoTo 10
Close 1
Return



hand:
'If Erl = 10 Then Resume 11
'If Erl = 20 Then Resume 11
'If Err = 62 Then Resume 11
Stop
Resume Next

End Sub

Private Sub Dir1_Change()
File1.Path = Dir1.Path

End Sub

Private Sub Drive1_Change()
Dir1.Path = Drive1.Drive
End Sub

Private Sub File1_DblClick()
Text1 = Dir1.Path + "\" + File1.List(File1.ListIndex)
End Sub

Private Sub Text2_DblClick()
CommonDialog1.FileName = "*.dat"
```

```
CommonDialog1.Action = 1
Text2 = CommonDialog1.FileName

End Sub
```

7.5 PISA Conversion Programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)

Private Sub Command1_Click()
On Error GoTo hand
Close 1

' Lettura dati FIX

ReDim xx(70000) As Single, yy(70000) As Single, timeVectors(100, 3)
Dim xmin As Single, xmax As Single
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True: ntv = 0
file = Text2 '"c:\loft_125.dat"
If Dir(file) <> "" Then
    Kill file
End If
Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0

ndesc = 0
Close 3

f$ = Text1
GoSub leggifile

Close 3
Close 2
MsgBox ("Conversion completed")
Exit Sub

leggifile:
Form1.Cls
Mid(f$, 1, 2) = Drive1.Drive
Form1.Print f$
Form1.Print "-------------------------------------------"
Close 1
Open f$ For Input As #1
For k = 1 To 3
    Line Input #1, A$
Next


2 Line Input #1, A$
If A$ = "" Then GoTo 2
While InStr(A$, "  ") <> 0
    A$ = Replace(A$, "  ", " ")
Wend
d = Split(A$, " ")
desc$ = d(0)
unit$ = d(1)
If InStr(A$, "TIME") <> 0 Then
    timevector = True
    desct$ = d(0)
    npunti = Val(d(2))
    nvect = Val(d(3))
Else
    timevector = False
End If
ndesc = ndesc + 1

Text3 = desc$

'timeVectors(ntv, 1) = tmin: timeVectors(ntv, 2) = freq: timeVectors(ntv, 3) = npunti
primo = True

5 npu = 0
ymin = 1E+30
ymax = -1E+30
Debug.Print desc$, tmin, freq, desct$
For k = 1 To Int((npunti - 0.001) / 6) + 1
```

```
    Line Input #1, A$
    For j = 1 To 6
        npu = npu + 1
        If npu > npunti Then GoTo 1
        dd = Mid(A$, (j - 1) * 13 + 1, 13)
        If Mid(dd, Len(dd) - 1, 2) > 35 Then
            Mid(dd, Len(dd) - 1, 2) = 35
        End If
        yy(npu) = Val(dd)
        If yy(npu) > ymax Then ymax = yy(npu)
        If yy(npu) < ymin Then ymin = yy(npu)

    Next j
Next k

1  GoSub scrivi

  GoTo 2

11 Close 1

Return

scrivi:
DoEvents

If InStr(desc$, "TIME") <> 0 And timevector = False Then Stop


If timevector = True Then
    ir = "R"
    itipo = 1
    desc$ = desct$
    npunti0 = npunti
Else
    ir = ""
    itipo = 2
End If
rec0 = rec0 + 1
Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npunti, itipo)
CwriteData file, rec0, yy(0), ymin, ymax, npunti, ir
Return

hand:
If Erl = 10 Then Resume 11
If Erl = 20 Then Resume 11
If Err = 62 Then Resume 11
Stop
Resume Next
End Sub


Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Private Sub Command2_Click()
On Error GoTo hand
Close 1
```

```
ReDim xx(70000) As Single, yy(70000) As Single, timeVectors(50, 3)
Dim xmin As Single, xmax As Single
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True: ntv = 0
file = Text2 '"c:\loft_125.dat"
If Dir(file) <> "" Then
    Kill file
End If
Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0

ndesc = 0
Close 3
Open Text1 For Input As #3
While Not EOF(3)
    Line Input #3, f$

    GoSub leggifile
Wend
Close 3
Close 2
MsgBox ("Conversion completed")
Exit Sub

leggifile:
Form1.Cls
Form1.Print f$
Form1.Print "-------------------------------------------"
Close 1
Open f$ For Input As #1

   Line Input #1, A$
2  Do Until InStr(A$, "IDENTIFIER") <> 0
20    Line Input #1, A$
  Loop
'If InStr(A$, "TEST CASE") <> 0 Then Stop
If InStr(A$, "DIRECTORY") <> 0 Then GoTo 11
If InStr(A$, "TIME") <> 0 Then
    timevector = True
Else
    timevector = False
End If
ndesc = ndesc + 1
desc$ = Mid(A$, 21, 12)
If InStr(A$, "HEAD") <> 0 Then Stop
If InStr(A$, "POINTER") <> 0 Then
    primo = False
    pointer = True
    timevector = False
Else
    pointer = False
End If
tmin = Val(Mid(A$, 51, 15))
freq = Val(Mid(A$, 66, 15))
Text3 = desc$ & " " & tmin & " " & freq


Line Input #1, A$

npunti = Val(Mid(A$, 26, 6))

Debug.Print npunti
If pointer = True Then
    If npunti <> npunti0 Then Stop
    GoTo 5
End If
If timevector = True Then GoTo 12
For k = 1 To ntv

    If tmin = timeVectors(k, 1) And freq = timeVectors(k, 2) And npunti =
timeVectors(k, 3) Then
        primo = False
        desct$ = "time" + Format(k, "000")
        GoTo 5
```

```
    End If
Next k

12 ntv = ntv + 1: 'If ntv = 4 Then Stop
desct$ = "time" + Format(ntv, "000")
timeVectors(ntv, 1) = tmin: timeVectors(ntv, 2) = freq: timeVectors(ntv, 3) = npunti
primo = True

5 npu = 0
ymin = 1E+30
ymax = -1E+30
Debug.Print desc$, tmin, freq, desct$
For k = 1 To Int(npunti / 5) + 1
    Line Input #1, A$
'    If A$ <> "  .000000000E+00  .000000000E+00  .000000000E+00  .000000000E+00
.000000000E+00" Then Stop
 '   Debug.Print A$
    For j = 1 To 5
        npu = npu + 1
        If npu > npunti Then GoTo 1
        xx(npu) = tmin + (npu - 1) * freq
        dd = Mid(A$, (j - 1) * 16 + 1, 16)
        yy(npu) = Val(dd)
        If yy(npu) > ymax Then ymax = yy(npu)
        If yy(npu) < ymin Then ymin = yy(npu)

    Next j
Next k
1 xmin = tmin: xmax = tmin + (npunti - 1) * freq

  GoSub scrivi

  Do Until InStr(A$, "IDENTIFIER") <> 0
10    Line Input #1, A$
  Loop
  GoTo 2

11 Close 1

Return

scrivi:
DoEvents

If InStr(desc$, "TIME") <> 0 And timevector = False Then Stop
If primo = True And timevector = False Then
    primo = False
    rec0 = rec0 + 1
    Call ScriviTestaFormato2(2, rec0, desct$, desct$, xmin, xmax, npunti, 1)
    CwriteData file, rec0, xx(0), xmin, xmax, npunti, "R"
End If


If timevector = True Then
    ir = "R"
    itipo = 1
    desc$ = desct$
    npunti0 = npunti
Else
    ir = ""
    itipo = 2
End If
rec0 = rec0 + 1
Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npunti, itipo)
CwriteData file, rec0, yy(0), ymin, ymax, npunti, ir
Return

hand:
If Erl = 10 Then Resume 11
If Erl = 20 Then Resume 11
Stop
Resume Next
End Sub


Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo)
Dim aa As String * 82
```

```
 rec = irec

 LSet cr$ = Chr$(10) + Chr$(13)
 ' scrivo prima riga
     aa = String$(80, 32)
     Mid$(aa, 1, 40) = desc$
     Mid$(aa, 50, 13) = format1(vmin)
     Mid$(aa, 65, 13) = format1(vmax)
     Mid$(aa, 42, 6) = "WgD2.1"
     Mid$(aa, 80, 1) = LTrim(Str(itipo))
     aa = Mid$(aa, 1, 80) + cr$
     Put nf, irec, aa

 ' scrivo la seconda riga
 irec = irec + 1
     aa = String$(80, 32)
     Mid$(aa, 1, 9) = LTrim(Str$(np))
     aa = Mid$(aa, 1, 80) + cr$
     Put nf, irec, aa

 ' scrivo la terza riga
 irec = irec + 1
     aa = String$(80, 32)
     Mid$(aa, 1, 40) = descTime$
     aa = Mid$(aa, 1, 80) + cr$
     Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
End Function


Private Sub Text1_DblClick()
CommonDialog1.FileName = ".txt"

CommonDialog1.Action = 1
Text1 = CommonDialog1.FileName
End Sub


Private Sub Text2_DblClick()
CommonDialog1.FileName = "*.dat"


CommonDialog1.Action = 1
Text2 = CommonDialog1.FileName

End Sub
```

7.6 PKL Conversion Programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)

Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo, unit$)
Dim aa As String * 82
rec = irec

LSet cr$ = Chr$(10) + Chr$(13)
' scrivo prima riga
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = desc$
    Mid$(aa, 50, 13) = format1(vmin)
    Mid$(aa, 65, 13) = format1(vmax)
    Mid$(aa, 42, 6) = "WgD2.1"
    Mid$(aa, 80, 1) = LTrim(Str(itipo))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la seconda riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 9) = LTrim(Str$(np))
    Mid(aa, 60, 10) = unit$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la terza riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = descTime$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
End Function


Private Sub Command3_Click()
On Error GoTo hand
Close 1
```

```
ReDim xx(70000) As Single, yy(70000) As Single, timeVectors(50, 3), freqV(100),
npoints(100)
Dim xmin As Single, xmax As Single
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True
file = Text2
If Dir(file) <> "" Then
    Kill file
End If

File1.Refresh

Close 2: Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0
ndesc = 0

FileTime$ = InputBox("Insert the time descriptor file", , "...tim.sif")
desct$ = "Time"

freq0 = 0
For k = 0 To File1.ListCount - 1
    fi = File1.List(k)
    If UCase(fi) = UCase(FileTime$) Then GoTo 1


Open Dir1 & "\" & fi For Input As #1
Open Dir1 & "\" & FileTime$ For Input As #3

Line Input #1, A$
Line Input #3, A1$
desc$ = Replace(Trim(A$), "  ", " ")
desc$ = Replace(desc$, " ", "_")
    npu = 0
    ymin = 1E+30: ymax = -1E+30
    DoEvents

    While EOF(1) = False
        Input #3, valuet
        If Trim(valuet) = "" Then
            GoTo 10
        End If
        Input #1, Value

        npu = npu + 1
        yy(npu) = Value
        xx(npu) = valuet
        If yy(npu) > ymax Then ymax = yy(npu)
        If yy(npu) < ymin Then ymin = yy(npu)
        If xx(npu) > xmax Then xmax = xx(npu)
        If xx(npu) < xmin Then xmin = xx(npu)
    Wend
10  Close 1
    Text3 = desc & " " & ymin & " " & ymax
    If primo = True Then
        ir = "R"
        itipo = 1
        rec0 = 1
        Call ScriviTestaFormato2(2, rec0, desct$, desct$, xmin, xmax, npu, itipo,
unit$)
        CwriteData file, rec0, xx(0), xmin, xmax, npu, ir
        primo = False
    End If
    itipo = 2
    ir = ""
    rec0 = rec0 + 1
    Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npu, itipo, unit$)
    CwriteData file, rec0, yy(0), ymin, ymax, npu, ir
    Close 1
    Close 3
1 Next k

Close 2
Close 3
MsgBox ("Conversion completed")
```

```
Exit Sub


hand:
'If Erl = 10 Then Resume 11
'If Erl = 20 Then Resume 11
'If Err = 62 Then Resume 11
Stop
Resume Next

End Sub

Private Sub Dir1_Change()
File1.Path = Dir1.Path

End Sub

Private Sub Drive1_Change()
Dir1.Path = Drive1.Drive
End Sub

Private Sub Text2_DblClick()
CommonDialog1.FileName = "*.dat"


CommonDialog1.Action = 1
Text2 = CommonDialog1.FileName

End Sub
```

7.7 UPTF Conversion Programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)

Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo, unit$)
Dim aa As String * 82
rec = irec

LSet cr$ = Chr$(10) + Chr$(13)
' scrivo prima riga
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = desc$
    Mid$(aa, 50, 13) = format1(vmin)
    Mid$(aa, 65, 13) = format1(vmax)
    Mid$(aa, 42, 6) = "WgD2.1"
    Mid$(aa, 80, 1) = LTrim(Str(itipo))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la seconda riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 9) = LTrim(Str$(np))
    Mid(aa, 60, 10) = unit$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la terza riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = descTime$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
End Function


Private Sub Command3_Click()
On Error GoTo hand
Close 1
```

```
ReDim xx(70000) As Single, yy(70000) As Single, timeVectors(50, 3), freqV(100),
npoints(100)
Dim xmin As Single, xmax As Single
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True
file = Text2
If Dir(file) <> "" Then
    Kill file
End If

File1.Refresh
Open "WGunits.txt" For Output As #3
Close 2: Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0
ndesc = 0
desct$ = ""
freq0 = 0
For k = 0 To File1.ListCount - 1
    fi = File1.List(k)



    Open Dir1 & "\" & fi For Input As #1
Line Input #1, A$
'Versuch:        RUN063
Line Input #1, A$
'Kanal -ID:  A400
Line Input #1, A$
d = Split(A$, Chr(9))
desc$ = Trim(d(1))
'Label:  JEC02CT064

Line Input #1, A$
'Ordinate:   Fluidtemperatur
d = Split(A$, Chr(9))
Ordinate$ = Trim(d(1))

Line Input #1, A$
d = Split(A$, Chr(9))
unit$ = Trim(d(1))
'SI -Einheit: °C
Print #3, desc$; "   "; Ordinate$ & " [" & unit$ & "]"

Line Input #1, A$
d = Split(A$, Chr(9))

freq = Val(Trim(d(3)))

Line Input #1, A$
d = Split(A$, Chr(9))
npunti = Val(Trim(d(2)))

'Erfaßte Daten:      5008
Line Input #1, A$
'Gemittelte Daten:       5008
Line Input #1, A$


newfreq = True
For j = 1 To nfreq
    If freq = freqV(j) And npunti = npoints(j) Then
        desct$ = "Time_" & j
        newfreq = False
    End If
Next
If newfreq = True Then
    nfreq = nfreq + 1
    freqV(nfreq) = freq
    npoints(nfreq) = npunti
    primo = True
    desct$ = "Time_" & nfreq
Else
    primo = False
```

```
 End If
 'Erfassung/Mittelung [Hz]:       25  25.000000


     npu = 0
     ymin = 1E+30: ymax = -1E+30
     DoEvents

     While EOF(1) = False

         Input #1, Value
         npu = npu + 1
         yy(npu) = Value
         xx(npu) = (npu - 1) / freq
         If yy(npu) > ymax Then ymax = yy(npu)
         If yy(npu) < ymin Then ymin = yy(npu)
         If xx(npu) > xmax Then xmax = xx(npu)
         If xx(npu) < xmin Then xmin = xx(npu)
     Wend
     Close 1
     Text3 = desc & " " & ymin & " " & ymax
     If primo = True Then
         ir = "R"
         itipo = 1
         rec0 = 1
         Call ScriviTestaFormato2(2, rec0, desct$, desct$, xmin, xmax, npu, itipo,
unit$)
         CwriteData file, rec0, xx(0), xmin, xmax, npu, ir
         primo = False
     End If
     itipo = 2
     ir = ""
     rec0 = rec0 + 1
     Call ScriviTestaFormato2(2, rec0, desc$, desct$, ymin, ymax, npu, itipo, unit$)
     CwriteData file, rec0, yy(0), ymin, ymax, npu, ir
 Next k

 Close 2
 Close 3
 MsgBox ("Conversion completed")
 Exit Sub



 hand:
 'If Erl = 10 Then Resume 11
 'If Erl = 20 Then Resume 11
 'If Err = 62 Then Resume 11
 Stop
 Resume Next

 End Sub

 Private Sub Dir1_Change()
 File1.Path = Dir1.Path

 End Sub

 Private Sub Drive1_Change()
 Dir1.Path = Drive1.Drive
 End Sub

 Private Sub Text2_DblClick()
 CommonDialog1.FileName = "*.dat"


 CommonDialog1.Action = 1
 Text2 = CommonDialog1.FileName

 End Sub
```

7.8 PSI Conversion Programme

```
Private Declare Sub CwriteData Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Single, ymin As Single, ymax As Single, ByVal nump As Long, ByVal itipo As String)
Private Declare Sub CwriteDataR Lib "leggidb.dll" (ByVal fi As String, r0 As Long, y1
As Double, ymin As Double, ymax As Double, ByVal nump As Long, ByVal itipo As String)

Function header(qua$, ymin1, ymax1, nump, ccmax)
Dim aa As String * 82

r1$ = String$(80, " ")
Mid$(r1$, 1, 8) = Mid$(qua$, 1, 8)
If Len(qua$) > 8 Then Mid$(r1$, 15, 12) = Mid$(qua$, 9, 12)

Mid$(r1$, 28, 1) = "W"
Mid$(r1$, 44, 5) = "gD1.1"
wgf$ = Mid$(r1$, 28, 1) + Mid$(r1$, 44, 5)
Mid$(r1$, 30, 13) = Str$(ymin1)
Mid$(r1$, 50, 13) = Str$(ymax1)
Mid$(r1$, 76, 4) = "    "
Mid$(r1$, 76, 4) = Str$(ccmax)
Mid$(r1$, 74, 1) = " "
l% = Len(Str$(nump)): Mid$(r1$, 9, 4) = Mid$(Str$(nump), 2, l% - 1)

header = Mid$(r1$, 1, 80) + Chr(13) + Chr(10)

End Function

Private Sub Command2_Click()
On Error GoTo hand
Close 1

' Lettura dati PSI
Dim desc$(1000), data(1000, 20000)
ReDim xx(70000) As Double, YY(70000) As Single, timeVectors(100, 3)
Dim xmin As Double, xmax As Double
Dim ymin As Single, ymax As Single
Dim aa As String * 82

primo = True: ntv = 0
file = Text2 '"c:\loft_125.dat"
If Dir(file) <> "" Then
    Kill file
End If
Close 2: Open file For Random As #2 Len = 82
ir$ = "" + Chr$(0)
rec0 = 0

ndesc = 0
kfile = 0
Close 3
Open Text1 For Input As #3
While Not EOF(3)
    kfile = kfile + 1
    Line Input #3, f$
    If f$ <> "" Then
        GoSub leggifile
    End If
Wend

Close 3
Close 2
MsgBox ("Conversion completed")
Exit Sub

leggifile:
Form1.Cls
Close 1

Open f$ For Input As #1
A$ = " "
ndesc = 0
While A$ <> ""
    Line Input #1, A$
    A$ = Trim(A$)
    If A$ <> "" Then
```

```
        ndesc = ndesc + 1
        A$ = Trim(Replace(A$, ",", " "))
        desc(ndesc) = A$
    End If
Wend

n = 0
npoint = 0
While EOF(1) = False
    n = 0
    npoint = npoint + 1
    For k = 1 To ndesc Step 6
        Line Input #1, A$
        'Debug.Print A$
        If Trim(A$) = "" Then
            Line Input #1, A$
            'If EOF(1) Then GoTo 10
        End If
        If Len(A$) = 0 Then Stop 'Exit For
        For j = 1 To 6
            If Trim(Mid(A$, (j - 1) * 14 + 1, 14)) <> "" Then
                n = n + 1
                data(n, npoint) = Val((Mid(A$, (j - 1) * 14 + 1, 14)))
'                If data(1, npoint) = 3448 Then Stop
'                If data(1, npoint) = 5417 Then Stop
            End If
        Next
    Next
    If EOF(1) = False Then
        Line Input #1, A$
    End If
Wend

10 xmin = 1E+30
xmax = -1E+30
np = npoint
For k = 1 To ndesc

    ymin = 1E+30
    ymax = -1E+30
    Debug.Print desc(k)
    For npu = 1 To np
        xx(npu) = data(1, npu)
        YY(npu) = data(k, npu)
        If xx(npu) > xmax Then xmax = xx(npu)
        If xx(npu) < xmin Then xmin = xx(npu)
        If YY(npu) > ymax Then ymax = YY(npu)
        If YY(npu) < ymin Then ymin = YY(npu)

    Next npu
    If k = 1 Then
        rec0 = rec0 + 1
        tdesc$ = desc(1) & "_" & kfile
        Call ScriviTestaFormato2(2, rec0, tdesc, tdesc, xmin, xmax, np, 1)
        CwriteDataR file, rec0, xx(0), xmin, xmax, np, "R"
    Else
        ir = ""
        itipo = 2
        rec0 = rec0 + 1
        Call ScriviTestaFormato2(2, rec0, desc(k), tdesc, ymin, ymax, np, itipo)
        CwriteData file, rec0, YY(0), ymin, ymax, np, ir
    End If
    Text3 = desc(k)
    DoEvents
Next k

'For k = 2000 To npoint:'

'    Debug.Print k, data(1, k)
'    MsgBox (A$)
'Next


11 Close 1

Return
```

```
scrivi:
DoEvents

If InStr(descr$, "TIME") <> 0 And timevector = False Then Stop
Return

hand:
If Erl = 10 Then Resume 11
If Erl = 20 Then Resume 11
If Err = 62 Then Resume 11
Stop
Resume Next

End Sub


'for k=1 to npoint:?k,data(1,k):next
Sub ScriviTestaFormato2(nf, irec, desc$, descTime$, vmin, vmax, np, itipo)
Dim aa As String * 82
rec = irec

LSet cr$ = Chr$(10) + Chr$(13)
' scrivo prima riga
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = desc$
    Mid$(aa, 50, 13) = format1(vmin)
    Mid$(aa, 65, 13) = format1(vmax)
    Mid$(aa, 42, 6) = "WgD2.1"
    Mid$(aa, 80, 1) = LTrim(Str(itipo))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la seconda riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 9) = LTrim(Str$(np))
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa

' scrivo la terza riga
irec = irec + 1
    aa = String$(80, 32)
    Mid$(aa, 1, 40) = descTime$
    aa = Mid$(aa, 1, 80) + cr$
    Put nf, irec, aa



End Sub


Function format1(A) As String
If Abs(A) < 1000000# And Abs(A) > 0.001 Or A = 0 Then
  f1 = Format$(A, "#####0.0####")
Else
  f1 = Format$(A, "0.0###E+##")
End If
format1 = f1
End Function


Private Sub Text1_DblClick()
CommonDialog1.FileName = ".txt"

CommonDialog1.Action = 1
Text1 = CommonDialog1.FileName
End Sub


Private Sub Text2_DblClick()
CommonDialog1.FileName = "*.dat"


CommonDialog1.Action = 1
Text2 = CommonDialog1.FileName
```

```
End Sub
```

Mission of the JRC

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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