



PMK-2 THE HUNGARIAN INTEGRAL TYPE TEST FACILITY: DOKUMENTATIONS, PUBLICATIONS AND ARCHIVATIONS OF EXPERIMENTS

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ABSTRACT

The **PMK-2** experimental facility at the KFKI-AEKI, Budapest, is a full pressure, scaled down model of the primary and partly the secondary circuit of the **Paks NPP**, which is equipped with four **VVER-440/213**-type reactors. Since the start-up of the facility altogether **48 experiments** have been performed for groups of transients as follows: one- and two-phase natural circulation, loss of coolant accidents, special plant transients and experiments in support of accident management procedures. The results have been used for the validation of thermal-hydraulic system codes for VVER applications.

Following the experiments a detailed documentation and archiving activity - using an optimised data storage - was required to preserve the essential information and to assure these for a widely utilisation for the international nuclear community. In the publication list related to the facility and the experiments for the moment altogether 280 items - documents, articles in periodicals, papers in proceedings and research reports - in six languages were collected.

The paper gives an overview on this activity including the participation in the EU CERTA-TN programme, where AEKI introduced representative databases of two PMK-2 tests in the STRESA Network.

1 INTRODUCTION

The preservation of the integral system experimental data bases for reactor thermal-hydraulic safety analysis - which are essentials to increase the reliance for the sophisticated codes - become one of the most important task of the research programs in last years. The ever-increasing power of computer hardware and software provides good background and

tools for the storage of the reactor safety experimental thermal-hydraulic databases and in the maintenance of the related documentation.

The **PMK-2** experimental facility [1] at the KFKI-AEKI, Budapest, is a full pressure, scaled down model of the primary and partly the secondary circuit of the **Paks Nuclear Power Plant**. This NPP is equipped with four **VVER-440/213**-type reactors. Such plants are slightly different from PWRs of usual design and have a number of special features, as 6-loop primary circuit, horizontal steam generators, loop seal in hot and cold legs, set-point pressure of passive safety injection tanks (SIT) higher than secondary pressure, etc.

To study the transient behaviour of this type of NPPs, to perform experiments for this special pressurised water reactor design the **PMK-NVH** facility was designed and constructed in the early 1980s and was put into operation in 1985. This was the first and the only full pressure integral-type facility for VVERs, therefore there was a high international interest for the test results applicable for computer code validation. The first design of the facility was primarily intended for investigating operational and off-normal transient processes, as well as small-break loss of coolant accidents of Paks NPP by modelling the primary circuit of plant. This version was used until 1990. The abbreviation **PMK-2** is used after an upgrading in 1991. This upgraded version - first of all by addition of a controlled secondary heat removal system - extended the capability of the test loop to modelling transient processes evoked by initiating events in the secondary circuit or including accident sequences in support of accident management (AM) procedures.

For the facility the volume and power scaling ratios are 1:2070. Due to the importance of gravitational forces in both single- and two-phase flow the elevation ratio is 1:1 except for the lower plenum and pressuriser. The six loops of the plant are modelled by a single active loop. The core model consists of 19 electrically heated rods. The main circulating pump of the PMK-2 serves to produce the nominal operating conditions and to simulate the flow coast-down following pump trip. The horizontal steam generator of the VVER-440 is modelled in the primary side by horizontal heat transfer tubes between hot and cold vertical collectors. The emergency core cooling systems including the SITs, high and low pressure injection systems of the Paks NPP are also modelled. Transients can be started from nominal operating conditions.

Since the start-up of the facility altogether **48 experiments** [2] have been performed for groups of transients as follows: one- and two-phase natural circulation, loss of coolant accidents (LOCA), special plant transients and experiments in support of accident management (AM) procedures. The results have been used for the validation of thermal-hydraulic system codes for VVER applications.

2 THE EXPERIMENTS

The PMK-NVH/PMK-2 facility was used for experiments of **four Standard Problem Exercises of the International Atomic Energy Agency (IAEA)** [3]-[6] in the time interval of 1985 to 1995. The main objective of experiments was to provide a possibility to the interested international community for joint code validation exercises. The 1st (IAEA-SPE-1), 2nd (IAEA-SPE-2) and 4th (IAEA-SPE-4) exercises were based on SBLOCA tests, with a cold leg break of 7.4% with different availability of ECC systems. The 3rd (IAEA-SPE-3) exercise was a VVER-specific case namely the opening of the steam generator (SG) hot collector cover. In the exercises 26 countries participated (in SPE-1 17 organisations from 12 countries, in SPE-2 the numbers are 17/13, in SPE-3 19/15 as well as in SPE-4 19/15) and an extensive validation of thermal-hydraulic system codes was performed.

In the time interval of 1996 to 2000 in the framework of five **EU PHARE projects** - in co-operation with AEAT, FRAMATOM, SIEMENS, IPSN, GRS, FZR and VVER-440 owner

countries – **ten** tests and in framework of **US-NRC CAMP project one** experiment have been performed with the aim of obtaining additional experimental data to support, among others, the development and qualification of Accident Management (AM) measures and the safety improvements programme of the Paks NPP. The experimental data were used to validate thermal-hydraulic code-systems for VVER applications as the ATHLET, CATHARE and RELAP5. Test types are as follows: inadvertent opening of pressuriser safety valve; rupture of pressuriser surge line; LOCA from the primary to secondary circuit (PRISE); small break LOCA with AM actions like primary and secondary bleed and feed.

To give further experimental support to the safety reassessment of the Paks NPP different **national research projects** were fulfilled. In this national framework altogether **26 PMK experiments** have been performed. **Seven** tests were performed to study special processes and to make preparations for experiments mentioned above.

3 THE PUBLICATIONS

Following the experiments a detailed documentation and archiving activity - using an optimised data storage - was required to preserve the essential information and to assure these for a widely utilisation for the international nuclear community. In the publication list related to the facility and the experiments altogether, till now 280 items - documents, articles in periodicals, papers in proceedings and research reports - in six languages were collected.

In the first group of publications are the documents including PMK-2 Handbook [1], summary on IAEA SPEs in TECDOC series [3]-[6], final reports on results of different PHARE projects [7]-[10], issues in US-NRC NUREG/IA series [11]-[12], or other documents as Refs. [13]-[15].

In the four IAEA TECDOCs the SPE test specification report, report on initial and boundary conditions and the measured test data report are summarised. Abstracts (input model description with nodalisation) and comparison figures of selected parameters from 17/17/23/15 pre-test papers and 7/4/12/17 post-test presentations are presented (for details see **Table 1**). Finally it is completed by evaluation of the exercise.

The next group of publications is the articles published in periodicals as Refs. [16]-[21]. In the biggest group the presentations from different meetings and conferences are collected which come out in Proceedings. Refs. [22]-[24] are examples for authors from different countries. The research reports are divided in two stacks, there are handled separately our KFKI AEKI reports written mostly in Hungarian and the reports from other institutions and organizations (examples for cooperation see [25]-[27]). A relatively small group comprises the university papers, dissertations and theses. The distribution by languages of 280 publications is presented in **Table 2**. In accordance with nationality of authors of the publications you can detect 24 different nations, an overview is shown in **Tables 3** and **4**.

4 PMK-2 IN CERTA-TN PROGRAMME

KFKI AEKI is participating in the **EU CERTA-TN** programme (European Thematic Network for the Consolidation of the Integral System Effect Experimental Databases for Reactor Thermal-Hydraulic Safety Analysis). The CERTA Thematic Network has been established and is partially funded under the Euratom Framework Programme 5 (Euratom-FP5), which implements in the period 1998-2002.

4.1 Objective of CERTA programme

Wide experimental research programs in thermal hydraulics have been carried out since the beginning of the nuclear era in the 60ies and are closely linked to the design and the safety

of nuclear plants. The extent to which the existing reactor safety experimental databases are preserved and can be eventually accessed and/or recovered is an issue often debated in the nuclear community. 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.

Country	IAEA-SPE-1 TECDOC 425			IAEA-SPE-2 TECDOC 477			IAEA-SPE-3 TECDOC 586			IAEA-SPE-4 TECDOC 848		
	a	b	c	a	b	c	a	b	c	a	b	c
Argentina	1	1	1									
Austria	1	1	1	1	1							
Brazil							3	3	2			
Bulgaria	2	2		1	1		1	1				
China	2	2		2	2		1	1		1	1	1
Czechoslovakia	2	3	1	1	2	1	1	4				
Slovakia										1	1	1
Finland	1		2	1	1		2	2		1	1	1
France										1	1	1
German D.R.	1	1		3	3	1	2	3	2			
Germany										3	2	3
Hungary	1	1		1		1	1		1	2	2	1
India	1	1	1	1	1		1	1	1			
Italy	2	2	1	2	2		1	1	1	2	1	2
Poland	1	1		1	1		1	1	1	1		1
Spain										1		1
Sweden							1	1	1			
Turkey				1	1	1	1	1	1			
United Kingdom										1	1	
USA							1	1	1	1	1	1
USSR				1	1		1	2				
Russia										1	2	1
Ukraine										1		1
Yugoslavia	2	2		1	1		1	1	1			
Croatia										1	1	1
Slovenia										1	1	1
Total	17	17	7	17	17	4	19	23	12	19	15	17

a = organization b = pre-test paper c = post-test paper

Table 1: Participations and presentations in IAEA Standard Problem Exercises

The objective of the CERTA-TN is to provide a consolidated framework for the preservation of the integral system experimental data bases 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 of the CERTA-TN actions include:

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

- the definition of optimized data storage and access requirements for the verification and validation of system codes used in reactor thermal-hydraulic safety analysis,
- the establishment of a user-friendly, web-based distributed informatics platform based on modern informatics technologies and provision of a demonstration package for remote data access and retrieval.

The network will include experimental programs and databases relevant to BWR, PWR and VVER reactors, which are in operation in the present and future EU member countries.

Publication	E	H	G	R	Sl	C	Sk	Total
Documents	18	1						19
Articles in Periodicals	7	1	2					10
Papers in Proceedings	132	1	1	5	1			140
KFKI AEKI Reports	19	56						75
Other Reports	20		5			2	2	29
Theses	1	3	1		2			7
Total	197	62	9	5	3	2	2	280

E = English, H = Hungarian, G = German, R = Russian, Sl= Slovene, C = Czech and Sk = Slovak

Table 2: Number of publications by their language

Publication	Int	H	Sl	G	US	Fi	I	C	Sk	O	Total
Documents	13	5				1					19
Articles in Periodicals	2	4	1		3						10
Papers in Proceedings	17	71	23	8	7	5	2		1	6	140
KFKI AEKI Reports	3	72									75
Other Reports	7		2	6		4	3	4	3		29
Theses		3	2	1	1						7
Total	42	155	28	15	11	10	5	4	4	6	280

Int = international (more than one nationality), H = Hungarian, Sl= Slovenian, Sk = Slovak, G = German, US = American, F = Finn, I = Italian, C = Czech and O = other nationality

Table 3: Number of publications by nationality of the authors

Publication	Int	a	b	c	d	e	f	g	h	i	Total
Documents	10				2				1		13
Articles in Periodicals		2									2
Papers in Proceedings	1	5	3	5		1	1			1	17
KFKI AEKI Reports		2				1					3
Other Reports		5	1					1			7
Total	11	14	4	5	2	2	1	1	1	1	42

Int = international (more than two nationality), H = Hungarian, a = H+German, b = H+Finn, c = H+Brazilian (IAEA), d = H+British, e = H+Slovak, f = H+Austrian, g = H+Slovenian, h = German+French, i = Italian+Slovenian,

Table 4: Number of publications by nationality of the authors (cont.)

Two main phases are provided in the CERTA-TN program. The first one, - this actually going on - is the feasibility/demonstration phase of the program; only the representative databases of two tests for each facility will be implemented in the network. The second phase (CERTA.2) will focus on the implementation and operation of the complete database of all available tests.

4.2 Results of the first phase

In the first phase of the programme the available experimental programs were summarized, information was collected from the facility operators [14]. This report contains the description of the facilities and the experiments performed. It describes the current practice in the storage of the reactor safety experimental thermal hydraulic database and the related documents. The following **experimental programs** (organisation, country) are involved: **PKL** (Framatome ANP, Erlangen, Germany), **BETHSY** (CEA, Grenoble, France), **SPES** (SIET, Piacenza, Italy), **LOBI** (JRC, Ispra, EC), **UPTF** (Framatome ANP, Mannheim, Germany), **PIPER-ONE** (ENEA/Pisa University, Italy), **FIX-II** (Studsvik, Sweden), **PACTEL** (VTT Energy/Lappeenranta University of Technology, Finland), **PMK** (KFKI AEKI, Budapest, Hungary), **PANDA** (PSI, Villingen, Switzerland). These are related to the European major integral test facilities.

In the second step a definition of an optimised data storage and retrieval guideline was prepared with the following content:

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

In the third step according to the previously gathered knowledge base a user friendly, web based distributed informatics platform was prepared and implemented. This is the **STRESA Network**, which 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.

4.3 KFKI AEKI contributions

KFKI AEKI introduced also two PMK tests in the STRESA network using an external database in the Internet network as the local STRESA_AEKI Database. As representative databases of two experiments from Standard Problem Exercises of the IAEA were selected: the test of steam generator collector cover lift up (IAEA-SPE-3) and the test of 7.4% cold leg break LOCA with secondary bleed and feed (IAEA SPE-4). That can be located at the http://guba.aeki.kfki.hu/stresa_aeki web address.

5 CONCLUSIONS AND REMAINING WORK

The CERTA network has been successfully set-up. It was 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 can be easily operated and guarantees that the data owner can track their users and control any operation on their database.

Now the way is open to the implementation and operation of the complete database of all available tests, - as mentioned above - in the next phase of CERTA NT programme. KFKI AEKI will complete the documentation and archiving activity to make possible to introduce additional databases of PMK-2 tests in the STRESA_AEKI Database.

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