CONTRIBUTION FROM TWENTY-TWO YEARS OF CSNI INTERNATIONAL STANDARD PROBLEMS

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OF CSNI INTERNATIONAL STANDARD PROBLEMS
ORGANISATION FOR ECONOMIC CO-OPERATION
AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OECD European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of all OECD Member countries except New Zealand and Poland. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

- encouraging harmonisation of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;
- assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;
- developing exchanges of scientific and technical information particularly through participation in common services;
- setting up international research and development programmes and joint undertakings.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers. It was set up in 1973 to develop and co-ordinate the activities of the Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. The Committee’s purpose is to foster international co-operation in nuclear safety amongst the OECD Member countries.

CSNI constitutes a forum for the exchange of technical information and for collaboration between organisations which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of its programme of work. It also reviews the state of knowledge on selected topics of nuclear safety technology and safety assessment, including operating experience. It initiates and conducts programmes identified by these reviews and assessments in order to overcome discrepancies, develop improvements and reach international consensus in different projects and International Standard Problems, and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of co-operation, such as information exchanges, establishment of working groups and organisation of conferences and specialist meeting.

The greater part of CSNI’s current programme of work is concerned with safety technology of water reactors. The principal areas covered are operating experience and the human factor, reactor coolant system behaviour, various aspects of reactor component integrity, the phenomenology of radioactive releases in reactor accidents and their confinement, containment performance, risk assessment and severe accidents. The Committee also studies the safety of the fuel cycle, conducts periodic surveys of reactor safety research programmes and operates an international mechanism for exchanging reports on nuclear power plant incidents.

In implementing its programme, CSNI establishes co-operative mechanisms with NEA’s Committee on Nuclear Regulatory Activities (CNRA), responsible for the activities of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with NEA’s Committee on Radiation Protection and Public Health and NEA’s Radioactive Waste Management Committee on matters of common interest.
FOREWORD

Large transient thermalhydraulic system codes are widely used to perform safety and licensing analyses of nuclear power plants and also used in the design of advanced design reactors. Evaluation of the capabilities and the performance of these codes can be accomplished by comparing the code predictions with measured experimental data obtained on different test facilities. In this respect, parallel to other national and international programs, OECD/NEA (OECD Nuclear Energy Agency) Committee on the Safety of Nuclear Installations (CSNI) has promoted, over the last twenty two years some forty one International Standard Problems (ISPs). These ISPs were performed in different fields as in-vessel thermalhydraulic behaviour, fuel behaviour under accident conditions, fission product release and transport, core/concrete interactions, hydrogen distribution and mixing, containment thermalhydraulic behaviour. 80% of these ISPs were related to the working domain of Principal Working Group no. 2 on Coolant System Behaviour (PWG2).

The ISPs have been one of the major PWG2 activities for many years. The individual ISP comparison reports include the analysis and conclusions of the specific ISP exercises. A global review and synthesis on the contribution that ISPs have made to address nuclear reactor safety issues was initiated by PWG2 and writing a short overview report on this subject was approved by CSNI.
CONTRIBUTION FROM TWENTY TWO YEARS OF CSNI INTERNATIONAL STANDARD PROBLEMS

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ABSTRACT

This report provides very briefly an overview on the contribution of CSNI International Standard Problems (ISPs) to nuclear reactor safety issues. This CSNI activity on ISPs has been one of the major activities of the Principal Working Group no.2 on Coolant System Behaviour. Its domain extended from thermalhydraulics to several other accident domains following the main concerns of nuclear reactor safety, e.g., LOCA predictions fuel behaviour, operator procedures, containment thermalhydraulics severe accidents, VVERs, etc. ISPs are providing unique material and benefits for some safety related issues. Clearly, all the technical findings and benefits provided by ISPs are still needed and contribute to advancement of nuclear safety.

ACKNOWLEDGEMENT

This report has been extensively discussed and reviewed by PWG2 Task Groups (Thermalhydraulic Applications TG and Degraded Core Cooling TG) and by the PWG2 itself. A specific review was performed by Mr. J. Martinez, CSN, Spain.
**TABLE OF CONTENTS**

FOREWORD .......................................................................................................................... 5  
ABSTRACT ............................................................................................................................. 7  
ACKNOWLEDGEMENT .......................................................................................................... 7  
1. INTRODUCTION ............................................................................................................. 11  
2. GENERAL OBJECTIVES ............................................................................................... 11  
3. CONTENT AND TYPES OF ISPs .................................................................................. 12  
    3.1. ISP Specifications .................................................................................................... 12  
    3.2. ISP Content and Procedure .................................................................................... 13  
4. TECHNICAL DOMAINS COVERED BY ISPs .................................................................. 14  
5. TECHNICAL FINDINGS ................................................................................................. 15  
6. BENEFITS TO THE SCIENTIFIC COMMUNITY ............................................................ 17  
    6.1. Benefits to the host organization .............................................................................. 17  
    6.2. Benefits to the participants ..................................................................................... 17  
    6.3. Benefits to the Research Managers ....................................................................... 19  
7. CONCLUSIONS ............................................................................................................... 19  
REFERENCES ...................................................................................................................... 20
1. INTRODUCTION

Large transient thermalhydraulic system codes are widely used to perform safety and licensing analyses of nuclear power plants and also used in the design of advanced design reactors. Evaluation of the capabilities and the performance of these codes can be accomplished by comparing the code predictions with measured experimental data obtained on different test facilities. In this respect, parallel to other national and international programs, OECD/NEA (OECD Nuclear Energy Agency) Committee on the Safety of Nuclear Installations (CSNI) has promoted, over the last twenty two years some forty one International Standard Problems (ISPs). The first International Standard Problem (ISP) was organized in 1975 on the famous "Edward's Blowdown Pipe" experiment. These ISPs were performed in different fields as in-vessel thermalhydraulic behaviour, fuel behaviour under accident conditions, fission product release and transport, core/concrete interactions, hydrogen distribution and mixing, containment thermalhydraulics.

A global review and synthesis on the contribution that ISPs have made to address nuclear reactor safety issues was initiated by PWG2 and writing a short overview report on this subject was approved by CSNI.

This CSNI activity on ISPs has been undoubtedly one of the most unanimous. Why such an interest and which results have been obtained are the two questions that we will try to answer in this report.

We will provide some overview on the general objectives of ISPs, content and types of ISPs, and technical domains covered by ISPs. The sections dealing with technical findings and benefits to the scientific community will try to answer the two questions posed above, with some conclusions.

2. GENERAL OBJECTIVES

Within the scope of evaluating safety questions in the early 70's, it appears very soon from the technical nature of the problems that computer codes were the main tools for obtaining accident predictions from which safety measures could be verified or developed. Large programmes including code development, experimental testing and code assessment were initiated which focused in a first step on the main issue at that time, i.e. LOCA thermalhydraulics.

When OECD member countries realized the huge amount of studies which was required, they considered very rapidly that international exchanges of domestic programmes would be very beneficial for everyone. As a consequence, a period started in the 70's and in the beginning of the 80's where a large amount of results (codes and experimental data) were exchanged mostly freely between the OECD countries. CSNI contributed largely to such general exchanges, and provided its own competence in their development by initiating two kinds of particular activities:

- The first one was a direct extension of the results exchanges. It consisted in discussing and elaborating consensual conclusions on the capabilities or the deficiencies of these results in answering the safety questions towards they were directed. This generated the State Of The Art Report (SOAR) activity which became one among the major CSNI activities.

- The second one was aimed to share more detailed technical experience. Recognizing that code assessment is certainly one of the key activities because it is a direct measure of the capability in predicting plant situations, it was decided to organize common exercises where a specific test was chosen for code calculations and where the code predictions from the different participants were extensively compared and discussed in reference to the experimental results. By doing such an exercise very detailed and basic technical exchanges can take place between experts. This generated the so called International Standard Problem (ISP) activity which is certainly a major CSNI activity and which is discussed in this paper.
3. CONTENT AND TYPES OF ISPs

In order to better understand which contribution the ISPs have provided to safety and why this contribution has been so beneficial, it is necessary to go in some details in the specifications and the rules which were set up for the performance of ISPs.

3.1. ISP Specifications

The key feature of an ISP is that it is centered on an experimental test.

This feature constitutes the main difference between ISPs and Benchmarks (following the definition made generally for these two activities in CSNI Working Groups). In a benchmark, the code predictions are made on a physical case defined theoretically for which no experimental reference can be used in the comparisons between the different calculations. On the contrary, in an ISP, the final quality of the predictions is judged on the experimental results themselves which play consequently a key role. This role has to be in fact carefully precised in the ISP specifications, and in the way the experimental data are distributed. These two points are particularly important for the ISP’s significance.

- **The ISP specifications** include all the data necessary for performing the code calculations, for instance the geometrical characteristics, the facility instrumentation and measurements locations, the experimental boundary and initial conditions, the main actions taken during the test,... These specifications are directly derived from the test itself. In fact, during the successive ISPs, the content of the specifications has been progressively precised. The governing idea has been to put the ISP participant in the same situation as the one in which he is when he is proceeding to a plant calculation for solving a safety issue. Therefore, in the last ISPs, results like those from characterization tests giving for example pressure drops, pump characteristics, heat losses and their distribution, etc., have been added in the specifications to the test conditions itself. Furthermore, for ISPs in relation to actual plant transients, additional specifications were supplied such as the timing and degree of interventions from operators as well as plant auxiliary system conditions with their uncertainty bands.

- **For the distribution of the test results**, different options have been used, which lead to the distinction between different types of ISPs: open, blind, semi blind, double blind. These options due to their importance must be explained in more details.

  - **Open ISP** is an ISP where the participant gets all the experimental data from the very beginning. All information is open.

  - **Blind ISP**, on the contrary, is an ISP where the participant has no access to the test results except the test boundary and initial conditions in the general meaning discussed above. Actual test results remain locked until the calculations are made and sent to the ISP organizer. The participant is doing his calculation in a blind situation, in the same way he is doing for the calculations of plant accidents where there is no experimental data available. Blind ISPs are consequently recommended because they better reflect the real conditions in which an analyst will find himself for plant analysis. Furthermore this is reinforced by the very frequent observation that calculations are generally much better when experimental results are available at the time of calculation. This is due to the adjusting of the computer model or input data to account for the specific test results. Calculations in blind situation may avoid most of this kind of "tuning effect".

  - In reality, even in blind situations, some tuning of the code may be obtained by using in fact tests which have been already performed on the same experimental apparatus and which may be more or less similar to the one proposed for the ISP. For this reason, distinction was often made in ISPs between real blind participation cases and participations in which the participant, in fact, had opportunities to perform extensive analysis of other tests in the same experimental apparatus and consequently participation could therefore
not be considered as completely blind. This is also why the concept of double blind ISP has been created.

**A double blind ISP** is an ISP for which the participant has not access to the results of the ISP test nor to the results of any other tests performed on the experimental apparatus (except the characterization tests considered as normal additions to tests conditions). This situation represents in fact the exact real situation of the analyst when he is performing plant calculations. Consequently double blind ISPs are especially challenging, to both the codes and the users of the codes, and correspondingly more valuable in assessing code performance. However such ISPs can only be performed in the very rare situations where no test results have been already published i.e. when starting a new test facility. In this situation, meeting the high quality of standards requested for ISP, is considerably difficult for the laboratory running the facility as it requires a perfect control of the experimental procedure which is in fact in contradiction with the learning phase generally experienced on a brand new experiment. Consequently very few double blind ISPs have been practically organised.

From the preceding discussion, it appears clearly that the more blind an ISP is, the more significant the conclusions may be. But there are cases where the generalisation of this statement is in fact an over-simplification.

**A semi blind ISP** concept has been introduced, for example, when the prediction of the tests involves two types of interacting phenomena and when the uncertainties on one of this phenomena will preclude the conclusions which can be drawn on the other one. In these specific cases it has been often decided, for preserving the ISP efficiency, that the results concerning the first phenomena will be open and the results of the second will be blind. This **semi blind** procedure has been for instance used for fuel behavior ISPs where thermal-hydraulic conditions were open and fuel results were blind so that uncertainties on thermalhydraulics will not prevent to draw conclusions on fuel behavior.

As an other example where blind ISPs are not providing necessarily the most significant conclusions, we can mention ISPs dealing with physical areas where the knowledge is at an early stage or dealing with areas where phenomena are particularly very complex. In such cases, blind calculations would give unusable results and valuable ISPs could only be open ones. In those specific areas, even if results of the ISPs look encouraging, it should not be forgotten that for such ISP, an open exercise has been chosen because of the difficulties expected in blind calculations and that consequently, one could also expect similar difficulties in the similar plant calculations which will be performed by the analysts in necessarily blind-like situation.

### 3.2. ISP Content and Procedure

After the delivery of specifications to the participant and after the collection by the organizer of the participant calculations, the comparisons between the different calculations and between the calculations and the experiment can be started. A draft report comparing the predictions to the actual data is prepared by the lead organization who collected the results. This document is distributed to the participating organizations and discussed at a subsequent workshop. This analysis is the most interesting part of the exercise. It provides the basis for drawing conclusions on the capabilities and on the deficiencies of existing calculational tools in an international framework. It is also during this analysis that the most detailed discussions can take place between experts. It leads to a final comparison report which is submitted to Principal Working Groups and to CSNI for issuance.

After issuing the comparison report, post-test activity on the ISP can start, if it seems useful and technically necessary. This can be initiated immediately or after some delay (one year or more depending on the new findings). It should involve the initial participants and eventually new organizations. In case of blind ISP, the participation of these new organizations will be considered as open (participation to the so called open-part of the ISP). The initial participants have the opportunity to perform post-test sensitivity studies on
the ISP in order to better analyse the results and in order to recommend improvements to
the analytical tools. An additive to the final comparison report is generally produced. It
constitutes most often a very valuable document as it complements the first analysis which,
due to the very considerable amount of available information, may not be complete, and as
it will incorporate the new findings obtained since then.

The procedures of handling all these ISPs activities have been well established and
improved when necessary (for further details see CSNI report no. 17 rev 3, November 1989,
on CSNI Standard Problem Procedures, [1]):

- For the decision about running an ISP, besides the recommendations or the wishes
  expressed by the Task Groups or the Principal Working Groups, the initiative is
  coming always and by principle from a host country which provides freely the test
  results and the means for making the comparisons (sometimes with collaboration of
  other organizations).

- After the check whether there is a consensus on the technical interest (some
  modification can be proposed at that stage) and that enough participation justify the
  organization of the ISP as offered, the specifications of the ISP are sent to the
  participants.

- A first workshop is held where these specifications are discussed and where all
  necessary information missing can be required by the participants and provided by
  the host country.

- A deadline for sending the contributions is agreed upon and after the receipt of the
  contributions, the host organization starts its comparison work. Reports of individual
  and collective comparisons are being written and distributed.

- A second workshop is then organized in order to collect the comments of all the
  participants on the draft comparison report and in order to share the different
  analysis. A final comparison report is then issued.

- If it is seen technically necessary and valuable, post-test activities can be initiated by
  the host organization. They are organized in the same way with workshops, draft
  reports and review process by the participants.

- During all the ISP process, special care is given for having equal treatment of all
  participants (diffusion of additional information, analysis of results, ...).

These procedures which may look complex, are in fact one of the keys contributing to the
success of the ISPs.

4. TECHNICAL DOMAINS COVERED BY ISPs

A compilation of all ISPs performed between 1975 and 1994 can be found with a brief
description of each ISP in the reports NEA/CSNI/R(94)19 and NEA/CSNI/R (97) 3, [2].

The very first ISPs from 1975 to roughly 1980 focused on LOCA thermalhydraulics as it was
one of the main concern of that time. We find there, ISPs based on separate effect tests
(Edward’s blowdown pipe, CISE blowdown test, Battelle blowdown test, tube reflooding test
ERSEC) and ISPs based on the two only available system experiments for PWRs at that
time i.e. SEMISCALE and LOFT.

After TMI, ISPs started to move from the Large Breaks to the Small Breaks. They included
ISPs on LOFT L3 small break LOCA series tests for PWRs, ROSA III test and FIX II test for
BWRs. Some large break tests were still selected: PKL reflooding test, as reflooding was
considered as a remaining issue; LOFT L2-S, as it was a significant "concluding" nuclear
test for large breaks.

During this period (beginning 80’s) two ISPs were initiated in a new domain for ISPs at that
time which was the domain of thermo-mechanical fuel behavior during LOCA. These were
ISPs on REBEKA test (non nuclear) and on PHEBUS LOCA test (nuclear).

In parallel to the ISPs dealing with the primary circuit, ISPs (in a first step called CASPs)
were organized in the beginning of the 80’s on containment experiments either system
experiments (BATTELLE Model Containment) or very small scale experiment (AAEC-Australia). These ISP's covered large break situations. They were followed in the mid 80's by ISP's on HDR containment tests (Large Break on PWR) and Marviken test (BWR).

During the second half of the 80's and during the beginning of the 90's, the ISP's related to thermalhydraulics were characterized by a full and coherent series based on the experiments which were decided and built after TMI in order to well study small break and transient situations including operator actions. They included ISP's on LOBI-mod2, SPES, ROSA IV, BETHSY for PWRs (lessons learned from these ISP's are provided in [3]), and PIPER ONE for BWRs. Besides this series, one ISP investigating the effect of non condensable gases on reflood was performed (ACHILLES), and the first and only one ISP based on real plant was organized in 1988 on the DOEL 2 steam generator tube rupture event.

End of the 80's, the interest of ISP's moved clearly to severe accident area. ISP's on core degradation were held based on CORA (non nuclear) and PHEBUS SFD (nuclear). Core concrete interaction was investigated with two ISP's (SURC4 and BETA2). Containment questions and especially hydrogen problems were the subject of two ISP's based on HDR and one ISP based on NUPEC test. Finally, ISP was also organized on FALCON to investigate Fission Product behavior with simulators.

The last recent extension of domain covered by ISP's is constituted by the move towards VVER related problems with PACTEL ISP (thermalhydraulics) and CORA VVER ISP (Core degradation).

In continuation of ISP's on thermalhydraulics and severe accident, shutdown states are being now investigated with a new ISP on BETHSY and steam explosions with an ISP on FARO.

This overview shows the extraordinary large range of technical domains which have been covered by ISP's. These domains reflect of course the successive changes in area of concern for safety research. This demonstrates also that the concept of ISP initiated in the thermalhydraulic area and extended to several other technical areas, is certainly very productive and useful. We will now analyse what are the outcome and the benefits produced by this activity and how it may explain its success.

5. TECHNICAL FINDINGS
The basic material of the technical findings from ISP activity is made of the several predictions obtained with several codes by several code users of a given physical experiment. From this material different cross-comparisons can be made which we will now review:

- The first class of comparisons are the comparisons between code predictions and experimental results. Such comparisons are evidently contributing to the code assessment. However some particularities to this contribution should be emphasized:
  - This assessment belongs of course to the "independent" assessment. Considering the generally very large number and very large variety of participants to ISP's, the "independent" character is certainly one of the most accentuate that we can afford. For those who are thinking that the independence of assessment is a very important feature, the results of ISP's are unique.
  - The number of code calculations in the comparison between code predictions and experimental results is certainly the largest that we can imagine on a single test. Almost no individual can do such work at least because of financial limitations. Besides this number of calculations, there are numerous differences in the physical models used in the different codes. The comparisons with experimental results are then very instructive on the effect of these models differences on the capabilities to predict the experiment. Often all codes available in OECD countries (and sometimes in the world) are represented during the ISP execution. A complete international view
is then obtained on the status of the predictive capabilities of the phenomena studied in the ISP.

- It is clear that the large amount of work produced by the participants and by the organizing country requires that no mistake should be done in the process. As a consequence, the experimental test must be first very carefully selected. Therefore it is very often one of the best and one of the most significant test of the experimental programme to which it belongs. The organization of the ISP requires also that all necessary information is transmitted to the participant in a very comprehensive way. Consequently, a very high control of test results and of documentation must be done by the organizing country. This last requirement led particularly the Working Groups to define standards for test documentation. These standards are summarized in the CSNI report no. 17 [1] and have shown to be quite general and useful, in particular as they have been used in several other areas than ISP. Finally the efforts made on the test selection, on the test control and on the test documentation provide most often a technical quality of very high level to the ISPs activities.

- The high level grade of documentation obtained by following the prescribed standards and the strict selection of the tests based on their physical and safety significance make the ISPs tests very good candidates for inclusion in validation matrices. ISPs tests may often be considered as international reference tests. Their already wide distribution and their consequent availability is also a favouring factor for such choices.

- The second class of comparisons is constituted by the comparisons between different codes. It is the common experience of analysts that understanding and analysing the code responses is a very difficult exercise. Indications are most often required in order to give directions for the analyst in its search of understanding the physical models pertinence. A first group of indications is given by the analysis of the discrepancies between calculations and experimental results which has been discussed above. A second group relates to the discrepancies between the results of different codes. This last group is often very valuable because the differences of models between the codes can be quite easily identified. Consequently the analyst can focus immediately on the concerned physical models and evaluate their relative capabilities in reference with the experimental data. By the wide variety of codes used, ISPs give good opportunities for doing extensive analysis of this kind.

- The last category of comparisons that ISPs allow, is the comparison of the results obtained with the same code by different users. The major differences between the calculations with the same code can be mainly attributed to the users of the code and this effect has been called the "User Effect". Indeed this effect is a major finding of ISPs activity. It has been discovered very early by running the very first ISPs on thermalhydraulics. The development of thermalhydraulic advanced codes was expected to decrease this effect, but the last thermalhydraulic ISPs have shown that there was still a significant "user effect" with these advanced codes. Detailed studies of this effect have been made on different ISPs and specially on ISP 26 [4]. In addition to the identification of the user effect, ISPs have contributed largely to its understanding. ISPs are really providing data which are absolutely unique on this crucial subject. Even though some suggested ways to reduce the user effect have been proposed, it remains that we are quite far from controlling it. This user effect has also appeared as a generic question and not only in the thermalhydraulics area where it has been discovered. In particular the several ISPs which have been recently performed in the severe accidents area have shown the importance of such an effect.
6. BENEFITS TO THE SCIENTIFIC COMMUNITY

Besides the technical findings which are shared equally by everyone, ISPs are providing general benefits which are specific, depending of the way the concerned people are involved in the ISP activity. Three types of involvement can be distinguished: the organizers (host) of the ISP, the participants to the ISP, the research managers who decide and fund research programmes and specially the ISP activity on a national level.

6.1. Benefits to the host organization

- For the host organization the ISP comparisons are providing a very broad analysis of the test they have proposed and certain a very broad and detailed analysis that they would not have in any case the possibility to have done by themselves. It is always of great value, in a large experimental programme, to have at least one of the tests very extensively analysed: By the views and recommendations that are provided, it may clearly benefit to the analysis of the other tests of the experimental programme and especially when the ISP test is one of the most significant test, which is often the case as we have indicated before.

- The large effort made for the test documentation may be very valuable to the general part of the ISP test documentation and hence to the overall experimental programme documentation. For instance, the needs expressed by the participants acting like “external customers” to get a comprehensive information, will induce very often addition in the tests documents of complementary information which was not initially foreseen. This will mostly contribute in the improvement of the documentation quality.

- Similarly questions raised by external people on the tests will often improve the general quality of the tests analysis, of the experimental findings, of the test data presentation and sometimes of the test data themselves. These are certainly indirect benefits, which are not obtained in every case, but which may be sometimes really significant.

- Having a large number of participants exercising on the same test of an experimental programme is a real opportunity for the host country to have comments and feedback from the international community on the main points of interest of his programme. Recognition on an international basis can be obtained, based on really detailed technical findings and not on more or less superficial feelings. This recognition may be also accompanied by a general consensus on how to solve the physical problems, giving the way to the host country on how eventually to improve his programme. The benefit will be obvious in that case.

If benefits cannot be denied for the host country and must not be therefore forgotten, it is clear that the host country is providing most of the effort which makes the success and the interest of the ISP. This effort has a significant cost but it is thanks to the results of this effort that other involved people are greatly benefiting from this activity.

6.2. Benefits to the participants

- The first benefit gained by the participant besides the technical findings to which he contributes, is certainly that ISP is an opportunity for him to have a privileged access to information on the experimental programme from which the ISP test has been selected. This benefit is all the more substantial since the corresponding experimental programme is a key programme in the safety research strategy. This is often the case and particularly for experimental programmes based on large systems installations. Two cases, at this point, must be distinguished:
  - In the first one, the participant, through bilateral agreement with the country providing the ISP, has already access to the experimental programme to which the ISP belongs and sometimes even in a broader way. Nevertheless, the experience shows that very often the high quality of standard of the ISP documentation remains for him the best way to enter practically in the total programme. Benefit of access through ISP is still real and may be considerable.
In the second case, the participant has no bilateral agreement. This occurs specially with the small countries. For this participant, as far as tests of multilateral programmes are generally not made freely available until some years have passed, the interest is obvious. ISP is for him a unique means to have access to detailed information and the benefit of access is crucial especially when the ISP test belongs to a major experimental programme.

Given that ISPs are chosen to cover the most important phenomena, and since an active participation of the recipient of the information is required through the ISP exercise, ISP is certainly a very efficient way for disseminating test results and for providing the subsequent important information on particular safety issue. As it has been seen before, this provides benefits especially to the small countries. But this serves also the interests of the major nuclear countries for whom it is very important to reach by means of an efficient exchange of information, a really world-wide good quality of safety related studies.

- The second benefit to the participants is that the ISPs give them an opportunity to have detailed technical discussions. These discussions are often going further than the ISP itself. Starting from exchanges of ideas on physical models related to the ISP, more basic questions are very often discussed such as questions on scaling, numerics, uncertainties, user effects. These questions which are sometimes treated "per se" in other CSNI activities, find here an excellent ground for discussion as they can be related to an experience commonly gained at the occasion of exercising on an ISP.

- Doing the ISP calculation provides to the participant a mean for evaluating his own capabilities in predicting the phenomena observed in the ISP. This is particularly true for blind ISPs. The benefits from this evaluation are strongly dependent on the participant:
  - For everyone, it represents a kind of competition which can be very stimulating and consequently positive. The idea of competition has never been really expressed explicitly in the ISP activity, but it is one of the major reasons for having strict rules in the organization of the ISP aimed to have an equal treatment of every participants as explained before.
  - For participants of major countries, the evaluation of their own capabilities in accident predictions can give a confirmation of their competence. Such confirmation has not been for most of the participants the major objective. However there have been certainly few cases where, related to this confirmation, participations to ISP have been cancelled because there was a fear that the results will not be as good as wanted for demonstrating this competence. This is clearly a drawback which cannot be avoided as far as comparisons are made between personal contributions. Most often, for this reason, the personal character was attenuated in the comparison reports by using for example cabalistic signs, but it never could be completely excluded.
  - For participants of small countries this evaluation has completely different goals and meanings. These countries are not generally developing the codes and are getting them through international agreements. For these countries, the participation in ISP is often a privileged and unique opportunity to perform by themselves independent assessment of the code that they have received and to exercise themselves as users of this code. The quality of the prediction is a mean for them to make their own judgement on the tools that they are using. By repeating this on several ISPs, they get a set of tests calculations which represents an important basis for judging the capabilities that these tools may provide to them for solving safety questions.

Lastly there are participants who are also starting in the code assessment activity, and for whom the ISP is in fact more or less a training exercise. As trained users are absolutely required for doing safety assessment, ISPs are providing here certainly a very valuable contribution which benefits mainly to the trainee. However we have to realize that it induces significant difficulties in the sense that the contributions of experienced and inexperienced users are mixed in the comparisons and that the
meanings of the discrepancies with the experimental results in both cases are not the same. It is quite difficult to get rid of this problem but it has to be taken into account in some way especially for some of the ISPs where there are many participants comprising necessarily some beginning users.

- Finally ISPs, as some other international activities, contribute in creating a real community of research people whose objectives are to improve their knowledge of physics in view of better safety studies. The activity of the ISPs is very propitious for this, as during a period of time, specialists from various countries are gathered in a common project which is to predict the same physical test and which is to discuss in detail their own contribution and the ones of their colleagues in order to draw conclusions on the ability in predicting accidents. This creates links between research people, a better knowledge of each other, and generally provides a privileged way to reach common understanding.

### 6.3. Benefits to the Research Managers

The picture given by an ISP, of a set of calculated results compared to experimental results, is certainly an objective measurement of the capabilities in the prediction of physical phenomena occurring during an accident. For the Research Managers, it should be therefore a privileged tool for answering questions such as, can the issue be considered as closed or is more research effort still needed.

It is clear that some care must be taken in this process. It is well known that results of an ISP can be presented in very different ways depending if one insists on agreements or if one insists on discrepancies. Excellent agreements on all parameters never occurred. More often there are at the same time agreements on some parameters and discrepancies on others. A well balanced judgement is then necessary. Exceptionally, there is a clear tendency for large discrepancies on every parameters. The calculation results are then obviously of low quality and one could expect clear conclusions in such case. Experience gained on ISPs have shown that these situations were in fact extremely difficult to handle as far as it appears very difficult and sometimes impossible to get recognition of the absence of positive results and especially when at the same time there were ongoing research programmes and even if one could expect that this absence was probably a temporary one.

In the case of combined situation with agreement and discrepancies, one can proceed by differences. Often the same phenomena is covered by several ISPs. One can then try to evaluate which progress has been made since the last ISP which has treated the same subject. This exercise has also shown sometimes to be very difficult as progresses in the predictions are not so obvious. This fact when it occurs should help the Research Managers in touching the real difficulty of the problems to be solved and in touching the necessary time for solving them.

For the Research Managers, besides the ISPs results, several other comparisons between calculations and experiments are available and especially those coming from domestic programmes. If ISPs by their own are certainly not sufficient to get a complete view, the "plus" they provided is that the view is much broader as it is extended to almost all the interested international community. Due to this generality, the conclusions which can be drawn should be consequently much more sound and this is certainly a very important point for defining and deciding about future research programmes.

### 7. CONCLUSIONS

After some adjustments at the very beginning, ISPs have become a well established activity. It extended from thermalhydraulics to several other accident domains following the main concerns of nuclear safety. Its success has been constantly increasing. The importance of the number of participants (more than 30) in some of the recent ISPs have even generated some real difficulties in handling the ISP. The outcome of these exercises
are constituted of both technical findings and more general benefits to involved people. About technical findings it has to be noticed the very wide comparisons which can be made between calculations and experiments and between calculations performed with different codes. The so called "user effect" has been demonstrated by ISPs and ISPs are providing unique material for its study. ISPs are benefiting to both the host organization and the participants. The high level of quality required for this activity is an incentive for the host organization and a way to promote its programme. For the participant, ISPs are giving him a privileged access to the results, a mean of performing code assessment, and the opportunity to have detailed discussions on several technical subjects more or less related to the ISP. This is particularly important for small countries. Research Managers may also find in ISPs, material for taking decisions about future directions for research.

In conclusion, ISPs helped in meeting several safety objectives, and namely by:

- contributing to a better understanding of postulated events and the physical phenomena involved,
- comparing and evaluating the capability of best estimate codes to predict controlled experiments and thus improving the confidence in them as assessment tools for safety issues,
- suggesting necessary improvements in the computer codes,
- providing means to assess the ability of code users, providing valuable experience and know how to be used in safety analysis of nuclear plants including licensing phases,
- providing information for quantifying safety margins in current design or licensing criteria,
- enhancing scientific discussion between computer codes developers and users in different countries.

It should be noted that ISPs have also provided reliable experimental data basis for OECD/CSNI validation matrices both for separate effects tests (SET) validation matrix [5] and integral test facility (ITF) validation matrix [6,7]. Most of the ISPs related to thermal-hydraulics have been integrated into these validation matrices.

All the technical findings and benefits which can be expected from ISPs are still needed. Therefore ISP activity should continue and one certainly can be confident that they will contribute, as they did in the past, to the improvement of nuclear safety.

REFERENCES

