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English - Or. English

NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

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CSNI INTERNATIONAL STANDARD PROBLEM PROCECURES

CSNI Report N°17 - Revision 4

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996); Korea (12th December 1996) and the Slovak Republic (14th December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC 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 28 OECD member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

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

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of senior scientists and engineers, with broad responsibilities for safety technology and research programmes, and representatives from regulatory authorities. It was set up in 1973 to develop and co-ordinate the activities of the NEA 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's main tasks are to exchange technical information and to promote collaboration between research, development, engineering and regulation organisations; to review the state of knowledge on selected topics of nuclear safety technology and safety assessments, including operating experience; to initiate and conduct programmes to overcome discrepancies, develop improvements and reach consensus on technical issues; to promote co-ordination of work, including the establishment of joint undertakings.

WORKING GROUP ON THE ANALYSIS AND MANAGEMENT OF ACCIDENTS

The Working Group on the Analysis and Management of Accidents (GAMA) is mainly composed of technical specialists in the areas of coolant system thermal-hydraulics, in-vessel protection, containment protection, and fission product retention. Its general functions include the exchange of information on national and international activities in these areas, the exchange of detailed technical information, and the discussion of progress achieved in respect of specific technical issues. Severe accident management is one of the important tasks of the group.

FOREWORD

This revised document was prepared under the Leadership of J.-C. Micaelli (IRSN). It was reviewed and endorsed in September 2003 by the Working Group on the Analysis and Management of Accidents (GAMA),

GAMA performed in 2003 a survey on updating CSNI Report No. 17, “CSNI Standard Problem Procedures”, first published in 1977, last updated in 1989. The objective of this activity was to collect proposals regarding the improvement of ISP efficiency with respect to their objectives and the improvement of the quality of the procedures document.

Eleven series of questions were asked in the survey, related to:

- General structure of the procedures document
- ISP objectives
- Six phases:
  - ISP proposal
  - ISP specification
  - ISP results reporting
  - Preparation of the preliminary data comparison and interpretation report
  - Post-ISP analysis
  - Preparation of the final comparison and interpretation report
- Updating of the procedures
- Support to be provided by the participants

INTRODUCTION

Assessing the safety of a nuclear installation requires the use of a number of highly specialised tools: computer codes, experimental facilities and their instrumentation, special measurement techniques, methods for testing materials and components and so on. These tools may vary to some extent in different countries and many of them are extremely complex and costly to produce and use. A highly effective way of increasing confidence in the validity and accuracy of such tools is provided by International Standard Problem (ISP) Exercises in which they are gauged against one another and/or against an agreed standard. For example, predictions of different computer codes for a given physical problem may be compared with each other and with the results of a carefully controlled experimental study which also could be a real plant transient. This kind of comparative exercise is clearly suitable for an international venture. CSNI is of the opinion that ISP exercises are useful and should be continued.

ISPs are performed as “open” or as “blind” problems. In an open problem results of an experiment are available to participants before it is evaluated. In a blind problem results of the experiment are not made known to the participants until after delivery of the calculated results. Depending on the kind of experiment and its objectives, certain boundary and initial conditions of the experiment are communicated to the participants before they start the exercise. This is necessary where it is difficult to guarantee the reproducibility of experiments. For all ISPs the participants are provided with a complete description of the experimental facility. The Lead Country (proposing the ISP) must decide whether the data can be withheld temporarily (blind ISP) or whether the data will be published before the analysis of participating countries is completed (open ISP). It is recommended that ISPs be conducted blind, where possible.

ISPs require a considerable expenditure of resources. Careful consideration and planning is therefore required. After a brief recall of the ISPs’ objectives, this document provides guidelines to be followed during the different phases of an ISP. Two phases are considered. The first one consists in proposing and selecting an ISP, the second one consists in performing an ISP.

I. Objectives of International Standard Problem

1. To contribute to a better understanding of postulated and actual events.
2. To compare and evaluate the capability of best estimate computer codes to predict controlled experiments and actual plant transients, and thus improve confidence in them as assessment tools for safety questions.
3. To highlight code deficiencies, if present.
4. To help users to evaluate the limits of their simulation process and thus to improve their ability.
5. To provide information for quantifying code uncertainties.
6. To suggest necessary experiments to reduce technical ambiguities brought out.
7. To evaluate the efficiency and practicability of the codes (in addition to their accuracy).

II. PHASE 1: Proposing and selecting an International Standard Problem

Figure 1 illustrates the procedures, activities and involved organisations during this phase.

Proposing

A written proposal should be provided by the Lead Country proposing an experiment for consideration as an ISP; the Host Organisation should be identified. The proposal should be concise but contain enough information on the experimental facility to decide whether the computer codes available can be used to treat the problem and what kind of data will be needed; complete information must be supplied after the ISP is selected.

The proposal should be sent to the Secretariat of the concerned Working Group (WG) for circulation to member countries at least 30 days before the next scheduled meeting of the WG and should include:

- Purpose of the ISP so that each member country can identify the possible benefits of performing the problem.
- Definition of the main physical phenomena of interest in the test selected, and discussion of the verification of major analytical models and individual models should be included.
- Description of the experimental facility (or plant) to give a sufficient understanding of layout and size, including:
  - drawing showing the overall facility layout;
  - drawings showing major components, and their characteristics;
  - details of experimental device where appropriate;
  - definition of material composition or properties; and
  - definition of boundary and initial conditions…

For real plants, this data can be made available as code input data

- Description and discussion of experimental facility or plant instrumentation or post test analyses, including:
  - a facility drawing with both types and number of instruments available;
  - location and type of instrumentation or analysis (e.g. post irradiation examination);
  - expected accuracy;
  - number of instruments from which recordings will be available; and
  - description of the data acquisition system including recording equipment, response time and sampling time.

- Description of experimental data available. If a blind ISP is proposed, how long the data would be locked up should be specified.

- Specification of test conditions in as much detail as possible. All configurational changes, details on initial/boundary conditions should be specified such that each member can understand the transient.

- For real plant transients, the timing and the degree of interventions from operators, as well as plant auxiliary system conditions, should be clearly stated, together with their uncertainty band, especially if those parameters cannot be retrieved from the available plant data base.

Selecting

The selection of ISPs should be based on the following:

- Relevance to the stated objectives and to the priorities of the WG.

- Availability of relevant codes and models.

Moreover:

- Integral and separate effect experiments may be considered, as also actual plant transients.

- The extension of the exercise to include:

  – Code uncertainty evaluation.

  – A follow-up with a full size reactor benchmark (or a larger scale ISP) must be encouraged (where possible).

- Blind exercise would be recommended (where possible).

The selection process is the following:

- WG:

  – Selection of ISPs from the set proposed.

  – Identification of participating Countries/Organisations.

  – Definition of the agenda (dates for specifications, comparison, preliminary and final reports, dates for workshops).

- Host Organisation:

  – Writing a CSNI Activity Proposal Sheet (CAPS, see appendix I) for selected ISPs.

- Secretary of the WG:

  – Transmission of CAPS (plus complementary documents if necessary) to Programme Review Group (PRG) and to CSNI.

- PRG
  - Review of the proposals and transmission of advice and recommendation to CSNI.
- CSNI
  - Endorsement with/without modification requests, or non endorsement.

III. PHASE 2: Performing the ISP

Figure 2 shows activities to be performed during this phase and the involved organisations. This phase contains five main steps.

STEP N°1: SPECIFICATIONS FOR INTERNATIONAL STANDARD PROBLEMS

Specification document

Within four to six months after the CSNI has endorsed the ISP, the Host Organisation should provide each participant with a document:

- recalling the general objectives of the ISP;
- describing in the detail the experimental process to be calculated;
- defining requests or recommendations on the way to perform the ISP and on the information to be provided by the participants (form and content); and
- defining the time table.

Description of the experimental process to be calculated:

- Experimental facility or plant description, including engineering drawings providing exact facility configurations (no assumptions on what is important). These drawings should include all dimensions, materials, and configurations of each part of the materials, and configurations of each part of the facility. The drawings should be of sufficient detail to allow detailed analytical models to be developed. Unambiguous descriptions of instrumental locations should be provided. All important dimensions of the facility and the test sections should be given in a table.

- In some cases, disclosure of all above data may be precluded for protection of proprietary data. The supporting documentation should however contain the minimum information required to perform an ISP, according to above objectives while the needed sensitive data could be transmitted in code input data deck form.

- Initial/boundary conditions to be assumed as actual initial/boundary conditions. For a blind ISP, initial/boundary conditions should be given as the planned values. If the data are to be withheld for a specified time, communicating measured initial/boundary conditions at a later date is suggested. A model developer would be able to use the planned values to formulate a simulation model and check it out. The analysis could then be performed using the measured initial/boundary conditions with very little change to the previous checked-out simulation model. For an open ISP, all the measured parameters should be specified and communicated to the participants. If specifically recommended initial/boundary conditions are given, a justification for using them should be provided.

- Experimental data to be available after the experiment is completed, including expected error bands as a function of time. This may help participants' selection of calculational nodes, considering which data will be available for post-test analysis. The format for data presentation should correspond to the format requirements specified for the calculated data.

Requests/recommendations:

- Requested results to be calculated. The points, the times at which parameter values are to be calculated should be specified. If these include points where experimental data are not available, this should be pointed out and the reason explained. The type of experimental measurements to which calculated results will be compared should be described: Participants can select average or point quantities that are sometimes available.

- Requested format to present the results. Format should be as simple as possible and accessible to all. Participants should be requested to strictly conform to the specified format for results (tables, plots). Units and data format should be standardised and all results should be in metric system units (SI units).

- Requested description of important (regarding ISP's objectives) characteristics and performances of the code such as: models, numerical scheme, mass and energy balance, meshing convergence, time for input deck preparation, CPU time per mesh…

- Request to use when they exist code default values and user guidelines (or best practice manuals) or to explain the reason why these reference rules have not been followed. Moreover, it should be recommended to provide at least in the frame of sensitivity studies a calculation using the same kind of methodology than that used for reactor calculation.

Timetable

The date by which the calculations are due and the date on which the experimental data will be released should be specified. If deadlines are changed by more than a month compared to timing agreed by CSNI, the Secretariat of the WG should be informed.

First workshop

- Within two months after the specification report has been issued, the Host Organisation should organise a first workshop:

  – to comment the specification document;

  – to clarify some points;

  – to answer participant questions; and

  – and to give the participants the opportunity to have exchange on their experience in the concerned simulation domain.

- The recommended duration of the workshop is 1.5 to 2 days.

- It is strongly recommended to invite developers of largely distributed and used codes to take part in the ISP exercise, in order to:

  – make them aware of specific developments required by the ISP (graphics, specific boundary conditions, etc.);

  – prepare them for the discussion of the results (especially for post-ISP phases); and

  – give them a clear view of necessary code improvements.

- In order to help non experienced code users it is recommended to invite developers of largely distributed and used codes to make a point on the current status of the code (development and assessment), focusing on modelling aspects of interest in the test selected.

- In order to take benefit of previous ISPs in the same domain, it is recommended to invite their organisers to present the main lessons of these ISPs regarding scientific aspects but also organisational aspects.

Complementary remarks and recommendations

- The participants should carefully review the ISP specifications for completeness and request any additional data deemed necessary.

- Where a complex experimental geometry is being studied, particularly for the first time, an additional meeting may be necessary to discuss input data problems prior to long computer runs being undertaken.

- During the exercise, the Host Organisation should provide written responses to all questions from the participants, with copies to all of the participants.

- The use of advanced communication tools is encouraged: mail, Web-site, …

STEP N°2: REPORTING RESULTS FROM INTERNATIONAL STANDARD PROBLEMS

The ISP should be calculated by each participating organisation and reported in conformance with the specification document. More, results reports should contain sufficient information to allow evaluation of the analytical models used, to provide guidance for future code development efforts, and to contribute to better understanding of phenomena. Therefore, the following should, be included in reports to be provided by participants:

A. Computer Codes

- Computer codes and versions applied should be clearly identified. Code descriptions should contain relevant information on the analytical models available, including appropriate equations and assumptions used in the derivation.
- Changes made to the computer code to perform the ISP that are not documented in the referenced code description should be described along with reasons for the changes.
- The method used to solve the system of equations and inherent limitations should be outlined.
- Code availability should be indicated.

Remark: Best-estimate computer codes (reflecting the state of the art) should preferably be used, nevertheless evaluation tool used in safety studies may also be used.

B. Simulation Model

- A description of the code application model used including nodalization, time step control, options selected, etc...
- Assumptions used in the calculation to simulate the experimental facility (physical properties).
- Specified initial/boundary conditions and assumed initial/boundary conditions used in the calculation.

C. Calculations performed

- Computer used and running time to perform the calculation.
- Results for all points and parameters specified in the problem specifications should be plotted and given in tables using metric system units (SI Units).
- Calculated results should be discussed briefly including interesting and unexpected results.
- Results should be plotted to further explain specific phenomena revealed during the calculation.

The results report is sent to the Host Organisation for comparison to experimental data and/or to other computational results.

STEP N°3: PRELIMINARY COMPARISON REPORT

The second step will consist in the preparation of the preliminary Comparison Report. The results are collected by the Host Organisation and a preliminary version of the Comparison Report is prepared. This preliminary document is then distributed to each participant for review prior to a second ISP Workshop.

Comparison report

The structure of the report should be the following:

A. Facility or plant Description

The experimental or plant facility should be discussed briefly. The description should indicate the position and error bands of experimental measurements, major components and positions for which calculations have been requested. Calculated results should refer to these descriptions.

B. Comparison of Calculated Results and Experimental Data

Plots of participants' results and corresponding experimental data with error bands should be shown. It may be necessary to present more than one plot per calculated position because of overlapping results or the need to use an expanded scale in one area.

Additionally, the comparison report should include:

- Compilation of codes and modelling features used by each participant.
- Comparison of specific results obtained with different computer codes (if suitable).
- Details of the assumed initial and boundary conditions for each participant.
- Results of additional parameters not requested for the comparison to the experiment.
- Information on deviations between planned conditions of the experiment and conditions actually achieved.

Regarding the code results comparison process, it is recommended to provide global comparisons but also specific comparisons between codes with equivalent levels of models and specific comparisons between results obtained with the same reference code version (when possible).

C. Explanation of Results

The experimental results should be discussed. Any deviation from expected results should be explained if possible.

D. Summary and Appendices

- The final version of the report must contain a short summary focusing on findings and most important conclusions on such things as improving certain aspects of analytical models, improving experimental information in specified areas, suggesting consideration of future standard problems.

- The final version of this report must contain an appendix where the Host Organisation briefly describes the main derived lessons in terms of ISPs' organisation. This appendix must take into account advices and comments of participants, which may be collected by the Host Organisation via an ad-hoc questionnaire.

- The final version of the report may contain an appendix compiling the results of Post-ISP analyses (see Step 4).

Second Workshop

Within two months after the preliminary comparison report has been issued, the Host Organisation should organise a second workshop:

- to present the ISP results;

- to propose and discuss preliminary interpretations and conclusions;

- to give the participants the opportunity to present complementary analyses (post-ISP analysis, see step N°4);

- to discuss and define if a post ISP Work Shop is needed (see step N°6); and

- to collect advices and remarks of participants on the organisational aspects of the ISP.

The recommended duration of this second workshop is 1.5 to 2 days.

In order to derive more clear and precise conclusions on the applicability of codes largely distributed and used, the Host Organisation should encourage code developers:

- to organise before the workshop an Users' Club meeting devoted to the evaluation of the results obtained with the concerned code; and

- to report during the workshop the conclusion of this meeting.

STEP N°4: POST-ISP ANALYSIS

This step is important; it starts after the transmission of the reference calculations to the Host Organisation, and can lead to a post ISP Work Shop (see Step 6).

The Post-ISP Analysis consists in sensitivity studies to determine which inputs of the codes require closest scrutiny; areas which may require additional study are, for example, time step convergence, nodalization or variation of code options. Particular attention should be paid to explaining:

- substantial deviations between calculated best estimate models and actual data and
- anomalous behaviour of evaluation models (compared to the data or to the best estimate calculations).

Each participant should be encouraged to carry on these analyses and should have the opportunity to present (if available in due time) them during the second workshop, and whatever, to include them as an appendix to the final comparison report, where he also can add any additional pertinent information to his previous results.

STEP N°5: FINAL COMPARISON REPORT, PEER REVIEW AND ACCEPTANCE

The final report should be prepared by the Host Organisation. It should be reviewed by all the participants, and then transmitted to the Secretary of the WG for a peer review.

The peer review is organised as follows:

- The Host Organisation proposes a list of possible reviewers among scientific experts of the concerned domain, and as far as possible non involved in the ISP.
- The Secretary of the WG in agreement with the Chairman of the WG defines the agenda of the peer review, selects the scientific reviewers, nominates a Quality Assurance (QA) Reviewer, and a Review Coordinator (in the case of GAMA the QA Reviewer is the “Quality Control Coordinator”, the Review Coordinator could be the “Coordinator for Computer Code Work”).
- The Secretary (or the Review Coordinator) sends a copy of the comparison report to all the reviewers.
- the reviewers send theirs comments to the Review Coordinator with a copy to the Host Organisation, to the QA Reviewer and to the Secretary of the WG.
- The Host Organisation takes into account the reviewers remarks and revises (in agreement with the Review Coordinator and the QA Reviewer) the comparison report, the revised report is then transmitted to the Secretary.
- The revised report is then distributed by the Secretary to all the WG members for complementary remarks, to be discussed during a WG meeting.
- The final remarks are then taken into account by the Host Organisation and a final draft is transmitted with four signatures to PRG and CSNI for final approval:
  - for the author: signature of one person of the Host Organisation;
  - for the scientific verification: signature of the Review Coordinator;
  - for the qa verification: signature of the qa reviewer; and
  - for the WG approval: signature of the WG chairman.

STEP N°6: (OPTIONAL): POST-ISP WORKSHOP

If substantial post-ISP calculations and analyses are performed or planned by different organisations, an additional post-ISP analysis workshop can be held at the request of the participants.

In order to provide a basis for systematic data comparison, it is recommended that such a post-ISP activity be organised following the procedure used for the ISP itself. This would include:

- the specification of a complete set of parameters to be calculated and compared (if this has been changed from the original set of values);
- the reporting of such details as the code version, input data and nodalization used; and
- the production of overlay plots of measured and calculated data, and the analysis of noted discrepancies.

The report of the post-test analysis workshop should be published as an appendix to the final comparison report.

FIGURE 1

ISP PROCEDURE PHASE 1
ORGANISATIONS INVOLVED AND RECOMMENDED TIME FRAME

LEAD COUNTRY/HOST ORGANISATION

PREPARATION OF A PROPOSAL

SUBMITTION TO RESPONSIBLE CSNI WORKING GROUP (WG)

30 DAYS BEFORE WG MEETING

↓

WG

DISCUSSION AND SELECTION OF ISPs FOR RECOMMENDATION TO PRG AND CSNI

↓

PRG

REVIEW AND RECOMMENDATION TO CSNI

↓

CSNI

ENDORSEMENT OF ADOPTED ISP PROPOSALS

↓

HOST ORGANISATION

PREPARATION AND DISTRIBUTION OF THE ISP SPECIFICATIONS

FIRST WORKSHOP (2 DAYS - 3 HALF-DAYS)

WITHIN 6 MONTHS AFTER CSNI APPROVAL OF ISP

FIGURE 2
ISP PROCEDURE PHASE 2
INVOLVED ORGANISATIONS AND RECOMMENDED TIME FRAME

PARTICIPANTS

PERFORMANCE OF CALCULATION AND SUBMITTAL OF CALCULATED RESULTS

WITHIN 6 MONTHS AFTER FIRST WORKSHOP

↓

HOST ORGANISATION

PREPARATION OF THE COMPARISON REPORT AND DISTRIBUTION FOR COMMENTS

WITHIN 6 MONTHS AFTER SUBMISSION OF CALCULATED RESULTS

↓

SECOND WORSHOP (2 DAYS – 3 HALF-DAYS) TO DISCUSS THE COMPARISON REPORT

2 MONTHS AFTER COMPARISON REPORT ISSUED

↓

UPDATE OF THE COMPARISON REPORT TRANSMISSION TO WG

↓

WG

ORGANISATION OF A PEER REVIEW

REVIEW AND DISCUSSION OF THE ISP RESULTS AND CONCLUSIONS

REPORT TO PRG AND CSNI

TWO YEARS AFTER ORIGINAL APPROVAL

PRG

REVIEW AND RECOMMENDATION TO CSNI

↓

CSNI

REVIEW AND APPROVAL OF ISP RESULTS AND CONCLUSIONS

↓

HOST ORGANISATION

PREPARATION OF THE FINAL DOCUMENT ON ISP EXERCISE

WITHIN 2 MONTHS AFTER CSNI APPROVAL OF REPORT

APPENDIX I

CSNI ACTIVITY PROPOSAL SHEET (CAPS)

Author

Title	
Objectives and expected products	Objectives: Expected products:
Scope /Justification	Scope: Justification:
Safety significance, use and users of the results	Significance in Safety Analysis: Use/Users:
Schedule and milestones	
Lead organisation(s)	
Participants	
Financing (if relevant)	
Requested action	

PRG comments	