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COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

CSNI LOCA STANDARD PROBLEMS

For clarity, this document, which was prepared by the CSNI Working Group on Emergency Core Cooling in Water Reactors, was tailored to the requirements of CSNI Standard Problems on Loss-of-Coolant Accidents. Adaptation to other types of standard problems (e.g. reactor containment standard problems) would be almost straightforward.

OECD Nuclear Energy Agency
38 boulevard Suchet, F-75016 Paris, France

CSNI LOCA STANDARD PROBLEMS

In the 3rd meeting of the CSNI Working Group on ECCS (August 1976), several countries expressed views on the scope of the Standard Problem programme and how often Standard Problems should be performed. Based on discussions expressed during the meeting and on some opinions, the following recommendations are made. The recommendations are divided into five parts:

I. Objectives of CSNI Standard Problems
II. Proposals for New CSNI Standard Problems
III. Specifications for Standard Problem Analysis
IV. Reporting of Results from CSNI Standard Problem Exercises
V. Calculated Results and Experimental Data Comparison Report

Because Standard Problems recommended by the Working Group on ECCS are expensive to analyze, each of the five sections given above should be carefully considered before executing a Standard Problem. It is this expense and possible benefit on the part of each participating country that would require the Working Group to consider, plan, analyze results, and draw conclusions for each Standard Problem performed. It was the expressed opinion of the group at the 3rd CSNI Working Group on ECCS meeting that Standard Problems have been providing a useful product and should be continued. This proposal is therefore an attempt to further clarify and improve the future Standard Problems.

Section I discusses the purpose for doing Standard Problems, and the other four sections discuss the different documents that should be prepared in support of the programme. Each of these four sections attempts to outline specifications for the content of the documents.

Figure 1 is a diagram of the proposed procedures, time limits, and required reports. The procedure is for each country willing to do so to propose an experiment and to write a proposal for the CSNI Working Group to review. It is important, for the country proposing the Standard Problem, to decide whether the data may be withheld temporarily ("blind" Standard Problem) or whether the data will be published before the analysis of participating countries is completed ("open" Standard Problem). This proposal for new CSNI Standard Problems should be sent to all countries before the Working Group meeting. In regularly scheduled Working Group meetings the following should be determined:

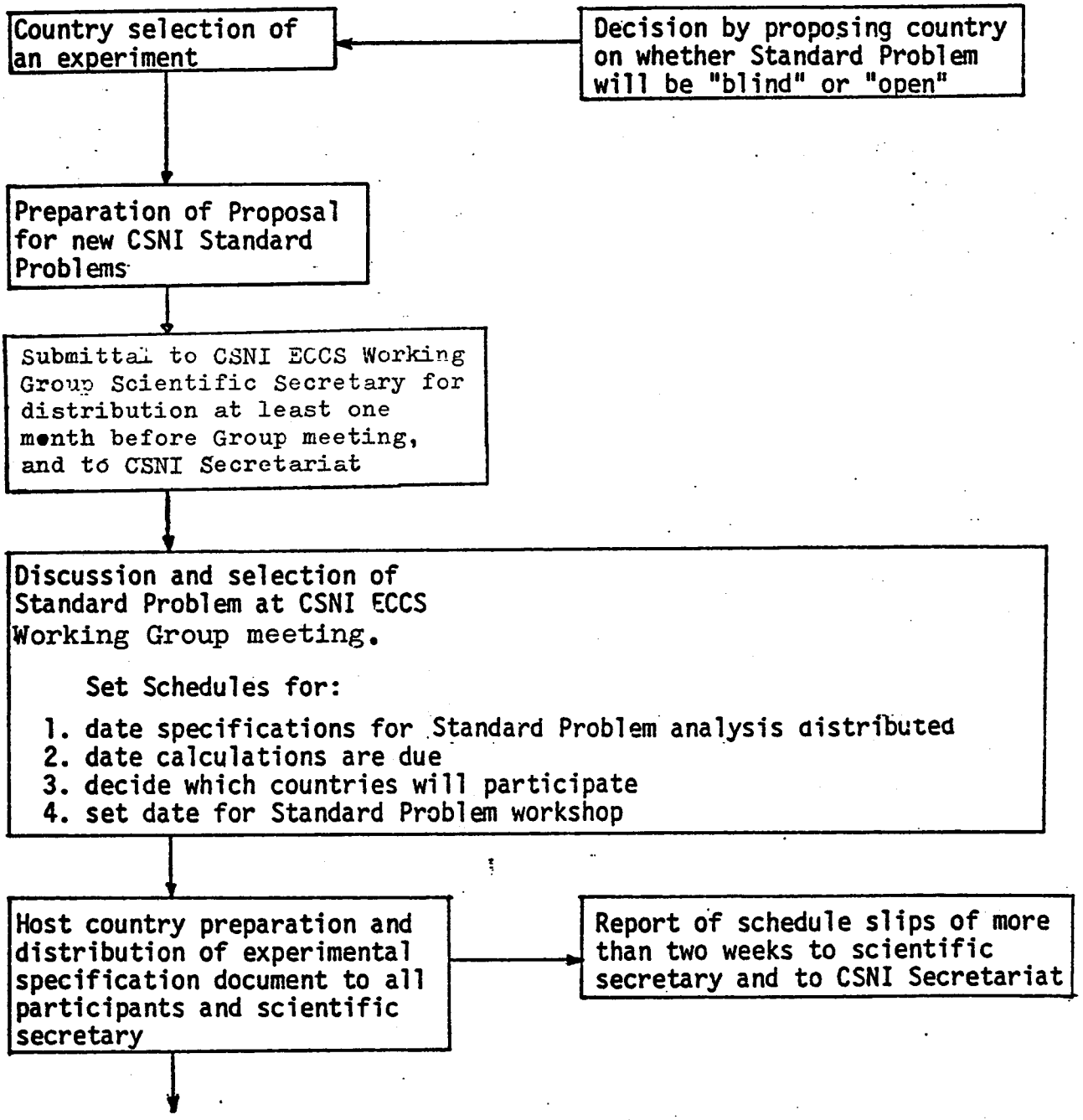
1. the selection of Standard Problems from the set of proposed Standard Problems;
2. dates for the detailed description;
3. date the calculation is due;
4. date of the next Standard Problem workshop; and,
5. which countries will participate.

These are important decisions to be made by the group since they involve several countries and a host country. For the selected Standard Problem, the host country should then prepare

the specifications for Standard Problem analysis documents and distribute them to each participating country. Because several countries are involved, slips in schedules, which often occur in experimental programmes, should be reported to the CSNI Working Group scientific secretary and to the CSNI Secretariat such that appropriate action can be taken. These actions could include changing schedules, changing to slightly different initial conditions and test conditions, or deferring the Standard Problem to a later date. The scientific secretary, in cooperation with a small group of volunteers should carefully review the specifications for the Standard Problem for completeness and request any additional data deemed necessary. The Standard Problem should be calculated by each country and reported in conformance as close as possible to the specifications outlined in Section IV "Reporting of Results from CSNI Standard Problems Exercises". This document is then sent to the host country for comparison to experimental data. The results are collected by the host country and a preparation of the Comparison of Results to Data document written as outlined in Section V. This document would then be distributed to each participating country for review before the Standard Problem Workshop. It is important for the group to draw a set of draft conclusions from these results at the workshop meeting. The draft conclusions should be prepared by the scientific secretary of the Working Group, and approval obtained from the Standard Problem participants. These would then be presented to the Working Group for adoption. These conclusions could include such things as improving certain aspects of analytical models, improving experimental information in specified areas, and suggesting consideration of future standard problems in certain areas. Figure 2 shows the documents which should be prepared by the participating countries, the host country and activities of the CSNI Working Group, scientific secretary and chairman and of the CSNI Secretariat.

STANDARD PROBLEM

SELECTION AND CALCULATION PROCEDURES



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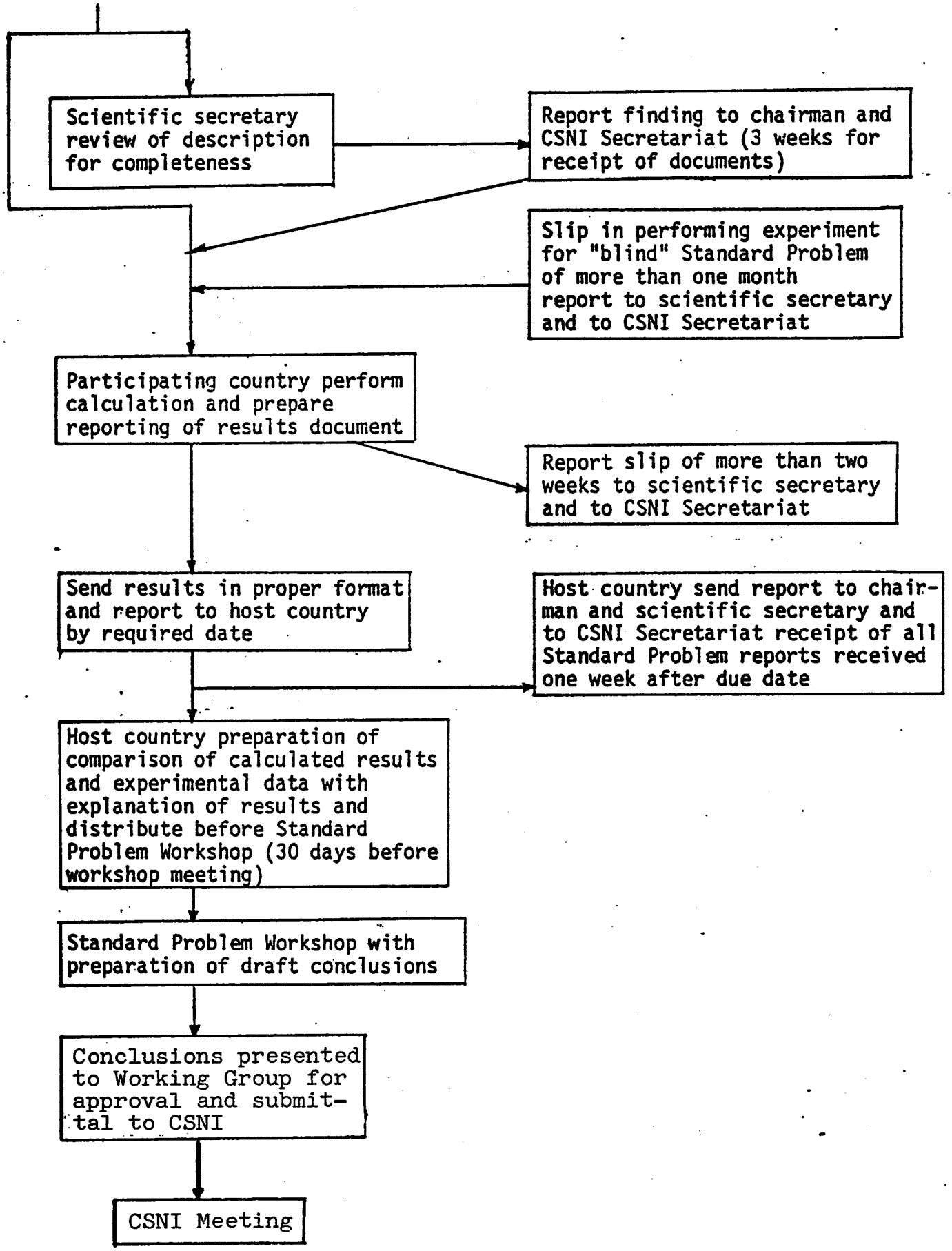
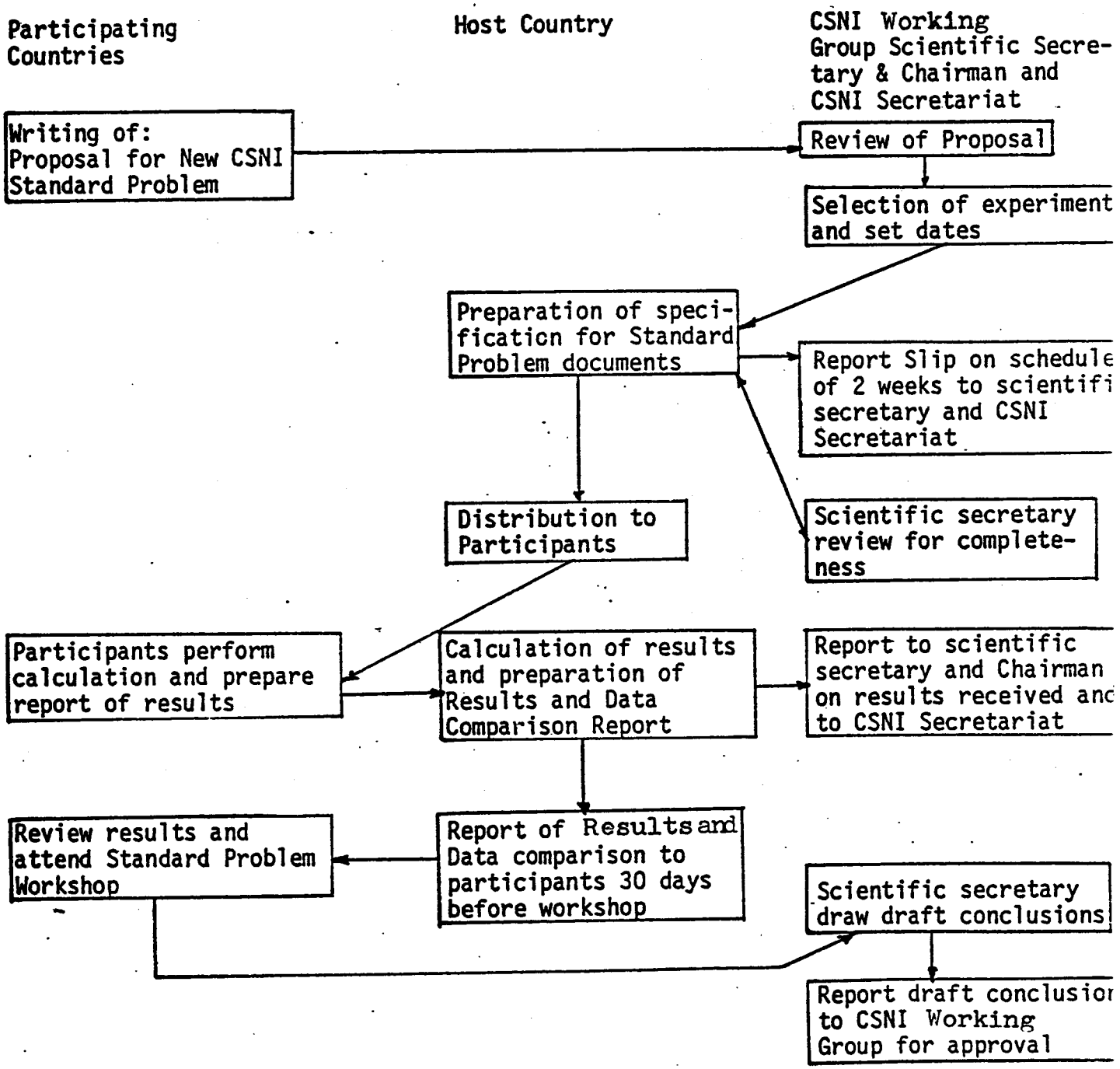

Scientific secretary review of description for completeness
Report finding to chairman and CSNI Secretariat (3 weeks for receipt of documents)
Slip in performing experiment for "blind" Standard Problem of more than one month report to scientific secretary and to CSNI Secretariat
Participating country perform calculation and prepare reporting of results document
Report slip of more than two weeks to scientific secretary and to CSNI Secretariat
Send results in proper format and report to host country by required date
Host country send report to chairman and scientific secretary and to CSNI Secretariat receipt of all Standard Problem reports received one week after due date
Host country preparation of comparison of calculated results and experimental data with explanation of results and distribute before Standard Problem Workshop (30 days before workshop meeting)
Standard Problem Workshop with preparation of draft conclusions
Conclusions presented to Working Group for approval and submittal to CSNI
CSNI Meeting

STANDARD PROBLEM

DOCUMENTATION PREPARATION



I. Objectives of CSNI LOCA Standard Problems Programme

The purposes for performing Standard Problems are:

1. To contribute to a better engineering understanding of the postulated LOCA event in a nuclear reactor and the interaction of the ECC systems.
2. To provide a comparison of best-estimate computer code calculations to experimental data under controlled conditions.
3. To evaluate the capability of computer codes in adequately predicting the consequences of postulated LOCA events in a nuclear reactor.
4. To provide the participating countries with information for adequately quantifying the safety margins in LOCA analysis with respect to their current licensing criteria.

To be of maximum use, the selection and analysis of Standard Problems should be based on the principles which follow:

1. The choice of Standard Problems must be made with utmost care for their relevance to the stated objectives.
2. Both integral and separate effect experiments are to be considered for Standard Problems.
3. Best-estimate computer codes will be used to perform Standard Problem analysis.
4. Results of the analysis should be fully documented.

II. Proposals for New CSNI Standard Problems

The performance of a Standard Problem, either separate effects or integrated, requires a considerable expenditure of resources and manpower of each country involved. Because of this, careful consideration and planning of each Standard Problem will

required by each member country. To accomplish this, a written proposal would be required by the country proposing the experiment for consideration for a new CSNI Standard Problem. This document should contain enough information for each country to make a study of the experimental facility and decide whether the available computer codes can be used to treat the problem and, in that case, what kind of data will be needed. This would require that the proposal be received by each member country at least 30 days before the next scheduled meeting of the Working Group. The proposal should include:

A. Purpose of Standard Problem

Purpose of Standard Problem must be specified such that each member country can conclude the possible benefits of performing the problem. The main physical phenomena of interest in the selected test should be defined clearly to facilitate an early check on the availability of relevant codes by each participant. Even in separate effects tests several portions of a computer code could be tested. Example of the purpose for performing the Standard Problem could be to test a portion of a code that is used in large reactor analysis (i.e., critical flow models, two-phase heat transfer models, fluid flow models, etc.). In this discussion the major analytical models (analytical models in computer programs) and possible verification of individual models should be included.

B. Experimental Facility Description

The experimental facility description should include enough information to give each reviewer a complete understanding of layout and size.

Included should be:

1. drawing showing overall facility layout;
2. drawings showing major pipe connections in facility (isometric drawing if possible);
3. pipe sizes and length; hydraulic characteristics of special components such as valves, pumps, etc; and,
4. details of test sections where appropriate.

Not all of this information need be submitted at the same time that an experiment is suggested as a Standard Problem. However, the host organization must be sure of the availability of this material before suggesting the case.

C. Experimental Facility Instrumentation

Instrumentation available in the proposed experimental facility should be discussed in general. Both types and number of instruments available should be given and specified on a facility drawing. Included in this discussion should be:

1. location and type of instrumentation;
2. relative accuracy and check available (i.e., mass and energy balance, as well as an estimation of the absolute accuracy of the measured quantities);
3. number of instruments that will be recorded; and,
4. description of data acquisition system including recording equipment, response time, and sampling time.

D. Availability of Experimental Data

This section should include a description of all the experimental data that would be available after the completion of the test. The question of whether this would be an "open" or "blind" Standard Problem should be answered. If a "blind" Standard Problem is proposed, the question as to how long the data would be unavailable should be specified.

E. Specification of Test Conditions

Specification of the proposed test conditions should be given in as much detail as possible. All configurational changes, details on initial conditions, and test boundary conditions should be specified where possible. This should be done in enough detail such that each country could specify the type of transient expected.

A brief information on these matters may be given when presenting the case for a first judgement. The complete information should be supplied when the case has been accepted.

III. Specifications for Standard Problem Analysis

Once the Working Group on ECCS has selected the Standard Problem to be analyzed, a detailed description is necessary. This document should be provided as soon as possible to each Standard Problem participant. Descriptions provided should be detailed and provide exact facility configurations (no assumptions to what is important) and detailed expected initial conditions.

Included in this document should be:

A. Detailed Experimental Facility Description

The writeup should include detailed engineering drawings of the facility as the test will be performed. These drawings should include all dimensions, material, and configurations for each part of the facility. Engineering drawings should be in sufficient detail to allow detailed analytical models to be developed, if desired. Care should be taken to provide unambiguou descriptions of test instrumentation locations. All important dimensions of the facility and the test section should be given in a table.

B. Results to be Calculated

The points at which calculated parameters are to be requested should be specified. If these include any points where experiment data are not available, these should be pointed out and the reason for its request explained. Some explanation as to the type of experimental measurement that the calculated results will be compared to should be included. This is important so that the participant can select average or point quantities that are sometimes available.

C. Format of Calculated Results

The host country will be responsible for collecting the calculated results from all other participants and plotting them together with the experimental data. To make this task possible, the host country should specify in detail the format for the results from all participants. All participants should then strictly conform to the specified format. Units should be

standardized and all results and data should be reported using metric system units (SI units).

D. Experimental Data Available

All experimental data that will be available to the Working Group members after the experiment is completed should be specified, including the error band as a function of time. In some cases this will help determine nodings chosen for the analytical model. It will also provide the participants with what data will be available for post-test analysis of their results.

E. Initial and Boundary Conditions

Initial conditions to be assumed as actual boundary conditions should be specified. In the case of performing a "blind" Standard Problem, the initial condition should be given as the intended value. If the data are to be locked up for a specified time, the possibility of specifying the measured initial conditions at a later date is suggested. Using this approach, a model developer would be able to use the best estimate condition to formulate a simulation model and check it out. Later the analysis should be performed with measured conditions with very little change to the previous checkout simulation model. In the case of performing an "open" Standard Problem, the measured initial condition should be specified.

Boundary conditions to be used by the model developer should be given and justification for their use specified.

The boundary condition should be measured experimental data wherever possible. If measured conditions are not used, assumptions should be given and justification specified.

F. Calculation and Experimental Data Reporting Dates

The date at which the calculated data are due and date of release of experimental data should be specified. This could modify the earlier proposed dates and modify the Standard Problem CSNI Working Group on ECCS approved schedule by no more than a month. If dates are changed by more than a month, the scientific secretary for the Working Group and the CSNI Secretariat should be informed for their concurrence.

IV. Reporting of Results from CSNI Standard Problem Exercises

To report the results of a Standard Problem exercise in a manner that would be useful to all countries requires the inclusion of certain elements. These elements include the computer program used, simulation model, specifics of the calculation and resulting data. Each of these four elements should be presented in such a way to allow a country to evaluate the analytical model used and provide some guidance to their use in future code development efforts. This will allow each country to evaluate specific analytical models and contribute to a better engineering understanding of the specific Standard Problem.

To help accomplish the purposes and goals of the Standard Problem exercise, the four elements should contain certain information. This is discussed below:

A. Computer Code

It is important that each country provide enough information about the computer codes used to allow evaluation of the results. The computer codes do not have to be published or available. However, sufficiently complete information must be made available on the models and assumptions in the codes that are used for Standard Problem computations. The computer code documentation should include:

1. a description of analytical models available including appropriate equations and assumptions used in the derivation;
2. descriptions of all changes made to the computer code to perform the Standard Problems analyses that are not documented in the basic code description. These should include equations and reasons for including the change;
3. descriptions of the numerical method used to solve the system of equations and inherent limitations;
4. whether the computer code is available to other countries or not. If so, how can it be obtained, what computer systems and core size are required;
5. whether or not several computer codes were used. If so, what analysis scheme and data transfer between programs should be given.

B. Simulation Model

It is important that the simulation model of the experimental facility be fully documented. This would aid each country in its evaluation of the results. This element should include:

1. complete description of the simulation model used including size and length of calculated mesh (node and junction descriptions).
2. assumption used in determining the experimental facility simulation model.
3. specified boundary conditions and assumed boundary conditions used in the simulation model.

C. Calculations Performed

A description of all computer runs should be included such that the evolution of the simulation model can be determined. The element should include a description of:

1. computer used to perform calculation;
2. description of all computer runs performed including CPU time and brief description of results obtained.

D. Results of Calculations

A good description of the results is necessary for both the host and other participants. The description should be as complete as possible and include the following:

1. Results should be included for all points specified by the Standard Problem specifications and reported using metric system units (SI units).

2. A short discussion of the calculated results (including interesting and unexpected results) that occur during the computation.
3. The participants should include any additional plots of calculated results which could further explain the phenomena that occurred during the calculation.
4. Type of computer and computer time (CPU time) used to produce the results if not included in item IV.C.2.

V. Calculated Results and Experimental Data Comparison Report

It is important that a comparison of experimental data and the calculated results be presented clearly for each participant. This allows each country to evaluate analytical models and simulation models used by others. Each participant's report of calculated results should also be made available to all members. This would aid in evaluating the results after the comparison to experimental data has been made. This report should contain the following elements:

A. Facility Description

A brief description of the experimental facility should be included. The description should include position of experimental measurements, major components and positions that have been calculated. Calculated results should be referenced to these descriptions.

B. Comparison of Calculated Results and Experimental Data

Plots of all participants' results and experimental data with the error bands should be shown. Scales on all plots should be in metric units (SI units) and scale size chosen for clear presentation of results. In some cases it may be necessary to present more than one plot of a given calculated position because the confusion of results or necessity of expanded scales in one area.

C. Additional Experimental Data

In some Standard Problem experiments more data may be available than that used for comparison purposes. If this arises all additional data should be presented. The additional data will allow the participants to make a comparison of other calculated results with experimental data.

D. Measured Boundary and Initial Conditions

If measured boundary and initial conditions are not available during the Standard Problem exercise, they should be included in this report. It would be important to report any deviation that might have occurred. The data could be used by a participant to perform post-test analysis.

E. Explanation of Results

To the extent possible the experimental results should be explained. Any deviations from expected results should be included. This aids each participant in explaining the difference between computed results and experimental data.

F. Post-Test Analysis

Post-test analysis is the most important aspect of the Standard Problem Programme. Participants should run sensitivity studies to determine what inputs to their codes require closest scrutiny. Various options and/or models should be tried to see how they affect results. Noding should be scrutinized to see if it was adequate for the problem. Examples of areas which may require study include break flow models, accumulators, pressurizer, steam generator, time step convergence, pumps, core nodalization or slip model. Additional computer runs should be executed as required.

Each participant will have an appendix in the final Standard Problem Report where he can discuss post-test analyses completed and can add any additional pertinent results. A discussion of why the code modeled the data results in the manner it did should be provided. Analytical results should be provided (when applicable) in support of explanations for deviations from data. Particular attention should be paid to explaining why substantial deviations occurred between calculated best estimate results and actual data. In particular, if the test data was outside the calculational error band submitted by a participant, explanation of the deviation should be provided. If an evaluation model preprediction calculation is to be supplied, anomalous behaviour of the evaluation model compared to the data or to be the best estimate calculation should be

explained. The time within which the post-test analysis should be completed should be decided at the CSNI Working Group meeting when the particular problem is chosen.