# THERMAL BENCHMARKING

*A status report**

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**Abstract**

THERMAL BENCHMARKING: A STATUS REPORT.

A series of benchmarks are being developed for evaluating codes used in the design and licensing of transportation systems for nuclear materials. The development of the benchmarks includes (1) definition of a problem set, (2) numerical solutions and (3) experimental verification. The first two steps have been completed and the plans for experimental verification are being developed. In conjunction with this domestic programme, a proposal was made to the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (OECD/NEA) for an international effort. A problem set was subsequently defined and agreed upon for the first phase of the international intercomparison of codes. The paper discusses the status and future activities of the benchmarking effort in the United States of America and reviews the status of international efforts.

## Problem Set

In defining the initial problem set, it is desirable to include problems spanning the three heat transfer mechanisms of conduction, convection and radiation. Further, since the hypothetical fire accident is the greatest thermal threat to a cask, it was decided to focus on simulations of this event. These two conditions resulted in the four problems shown in Fig. 1. The first problem is a simple cylinder with heat source and a convective boundary. This problem has a closed form numerical solution. The remaining problems deal with heat generation, conduction, and radiation building sequentially towards the fourth problem.

## Numerical Solutions

Numerical solutions were obtained using a variety of publicly available codes. The solutions to problems 1 and 2 were in excellent agreement, with less than a 1°C variation. In problems 3 and 4 there was greater variation. This was due to the use of gap radiation in some models. These could only approximate two-dimensional radiation effects. This resulted in underpredicting temperatures on the surface of the cask that faces the shield when compared to models that incorporated a two-dimensional radiation model.

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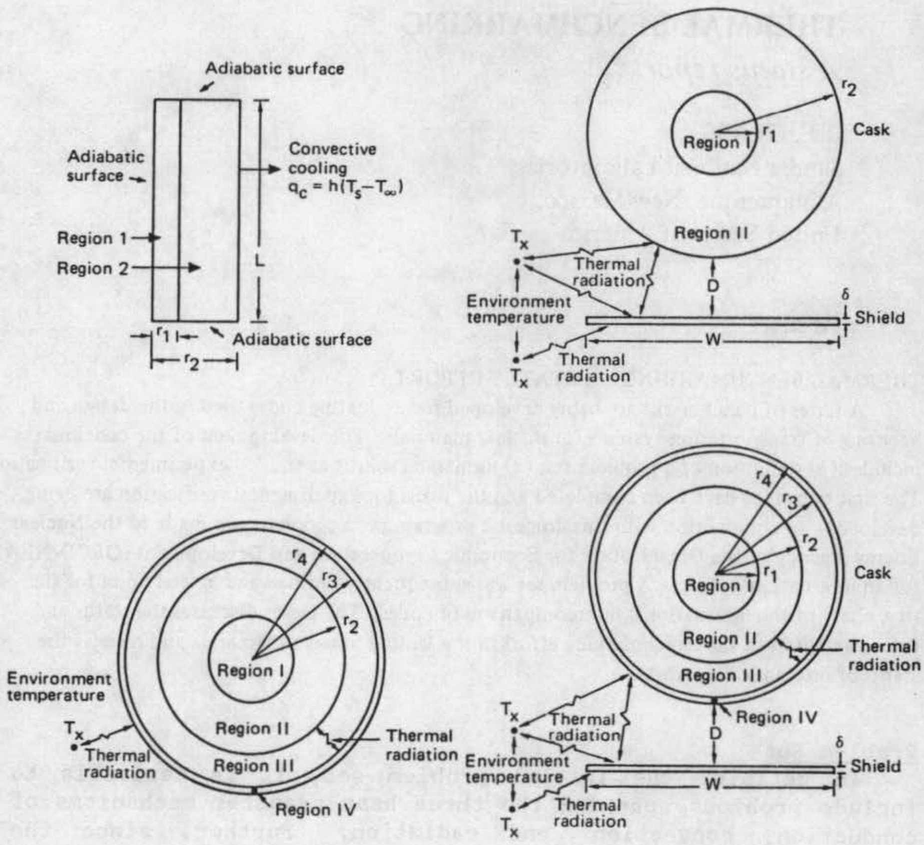


*FIG. 1. Benchmark problem set.*

These results led to consensus solutions for each of the problems as well as a greater understanding of the limits of the various codes. The remaining task is to develop experiments to obtain verification data.

Experimental Plans

A series of experiments are planned using the basic geometry of the benchmark problems. These experiments will be performed at Sandia's radiant heat flux facility. The test setup will include a 1.8 m (6 ft ) tall, 45.7 cm (18 in ) diameter shroud with computer-controlled temperatures. The heat source will be provided by strip heaters. Thermocouples will monitor temperatures at selected locations on the cask and shield. Following the establishment of a steady-state temperature profile, the shroud will be heated to 800°C and held at that temperature for 30 minutes. This will be followed by a 60 minute cooldown at ambient temperature.

While these experiments are designed around the initial benchmark problem set, there are significant changes due to facility limitations. These include (1) real emissivities of 0.95 as opposed to black body, (2) convective effects and (3) reductions in size. These real effects will be incorporated in a revised problem set and will be incorporated in the numerical models to complete these thermal benchmarks.

International Effort

As an extension of the US program, a proposal was made to OECD/NEA for a comparable effort on an international scale. The US proposal was reviewed at a Specialist's Meeting on Heat Transfer held in Paris, France, on May 2, 1985. At this meeting, the first and fourth problems were accepted for the thermal problem set. In addition, two problems submitted by the representatives of the United Kingdom were accepted. These included a problem requiring detailed analysis of a two-dimensional fuel-pin array and a plane-fin radiation problem.

Each of the nine nations participating in the effort were asked to provide solutions to this initial set of problems. The results will be reviewed to establish a common level of understanding, followed by adoption of an expanded problem set addressing concerns of mutual interest to the participants.