Chapter 1

INTRODUCTION

Of paramount significance in the development of new high temperature gas cooled reactor (HTGR) concepts is the predicted capability for this advanced nuclear plant to achieve a high degree of safety through reliance on passive safety features. Because of this, the investigation and validation of the safety and operational aspects of the HTGR were the primary focus for many of the coordinated research programmes (CRPs) initiated by the IAEA in the 1990s. These included:

- the neutronic physics behaviour of the HTGR core,
- fuel performance and fission product behaviour, and
- the ability of the HTGR to dissipate decay heat by natural transport mechanisms under accident conditions

The principal tools utilized in these CRPs included scientific research and engineering development through analytical evaluation of benchmark problems, application of new and/or existing computer codes and models and utilization of test apparatus and loops for specific component validation.

The next important step in bringing this advanced nuclear power programme from concept to actuality is to verify system performance and safety under actual HTGR operating conditions. It is the need for validation via testing in nuclear reactors that was the stimulus for the IAEA to initiate this CRP on "Evaluation of High Temperature Gas Cooled Reactor Performance".

The principal facilities utilized in the performance of this CRP included Japan's High Temperature Engineering Test Reactor (HTTR), China's High Temperature Test Module (HTR-10), and Russia's ASTRA critical assembly. Selected codes and models associated with the Gas Turbine Modular Helium Reactor (GT-MHR) and Pebble Bed Modular Reactor (PBMR) plant designs are also investigated within the scope of this CRP.

The objectives of this CRP include:

1. Validation of analytical codes and performance models to actual operating conditions of HTGRs,
2. Formulation of research and development code-to-experiment benchmark activities for inclusion into the test programmes for the HTTR, the HTR-10 and the ASTRA facilities,
3. Investigation of analytical codes and models associated with future HTGR gas turbine plants utilizing code-to-code benchmark problems, and
4. Demonstration of HTGR safety characteristics.

Overall, this TECDOC addresses performance based HTGR code and model verification during startup, steady state and transient operational conditions of the HTR-10 and HTTR test facilities are being evaluated. Also included within the scope of this CRP is the utilization of national research facilities and computer models to investigate the areas of core physics, safety characteristics of the HTGR, fission product release and transportation behaviour, thermal hydraulics, control response and high temperature component performance.

This TECDOC documents the benchmark problem results obtained by Chief Scientific Investigators (CSIs) from China, France, Germany, Indonesia, Japan, the Netherlands, Russia, South Africa, Turkey and the United States for the following areas:

- Reactor physics benchmark analysis of the HTTR including initial criticality, control rod worth, excess reactivity, scram reactivity and temperature coefficient of reactivity,

- Reactor physics benchmark analysis of the HTR-10 including initial criticality, temperature coefficient of reactivity and control rod (including differential) worth,

- Selected thermal hydraulic benchmark analysis for the HTTR including vessel cooling and loss of off-site electric power.

The presentation of this TECDOC is by facility and benchmark type with Chapter 2 devoted to HTTR core physics, Chapter 3 to the HTTR thermal hydraulic benchmark problems associated with vessel cooling and loss of electric power. Chapter 4 is devoted to HTR-10 core physics benchmarks. Each of these chapters includes a description of the test reactor, an overview of the benchmark problems being addressed, individual analysis by each Member State and a review of the actual test results of each problem as performed on the test reactor. Chapter 5 provides a collation of the results, general conclusions and recommendations for code and model improvements determined as the result of participation in the CRP.