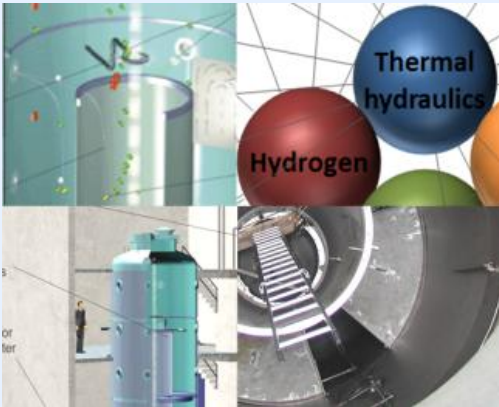


THAI-Facility & Program



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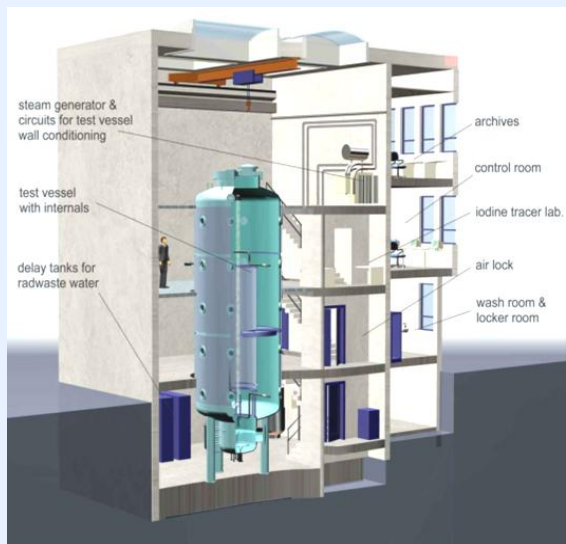
Background

Safety assessment and accident management in nuclear power plants necessitate investigating complex phenomena and processes with adequate accuracy. In support of such activities, the experimental THAI program, sponsored by the German Federal Ministry of Economics and Technology, aims at answering open questions on thermal hydraulics and on fission product and hydrogen behaviour in LWR containments.

THAI provides experimental data bases for Lumped-Parameter (LP) and CFD (Computational Fluid Dynamics) simulation programs in the area of reactor safety. Coupling of thermal hydraulics, fission product transport and chemistry is a main focus, especially for iodine with its high radiological importance.

THAI aims particularly at the validation of the containment code COCOSYS (Containment Code System) which is developed by the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH. COCOSYS is mainly based on mechanistic models for the comprehensive simulation of all relevant phenomena, processes and plant states during severe accidents in the containment of light water reactors, also covering design basis accidents.

THAI aims further to validate CFD codes. This class of codes (e. g. CFX, FLUENT) would allow a more detailed simulation of inhomogeneous atmospheric distributions, which is needed e.g. for the risk assessment of hydrogen combustion. Specifically for CFD code validation the experimental program is based on a strategy of



successive increase of complexity, beginning with simple momentum driven flow field investigations, then stepwise adding other physical interactions like buoyancy, heat exchange and steam condensation. THAI is complemented by experienced in-house usage of simulation programs (COCOSYS, GOTHIC) in order to support the experimental design and to allow for high reliability in data processing and interpretation.

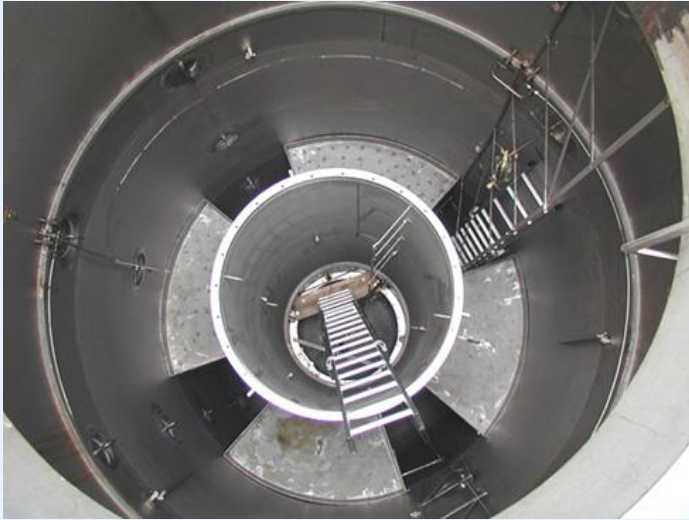
THAI – Facility

The THAI facility is a unique technical-scale plant, built for experimental research in nuclear reactor containment safety. The acronym THAI stands for Thermal-hydraulics, Hydrogen, Aerosols and Iodine. It includes a restricted area to utilise ^{123}I radio-tracer for iodine investigations.

The facility allows investigating safety relevant separate and combined effects in these areas under thermal-hydraulic

conditions, typical for severe accidents. Thermal-hydraulic scenarios can be simulated, ranging from turbulent convection to stagnant stratified containment atmospheres, and can be combined with hydrogen, iodine, and aerosol related processes.

THAI is equipped with innovative measuring, sampling and data acquisition systems.



Test Vessel and Instrumentation

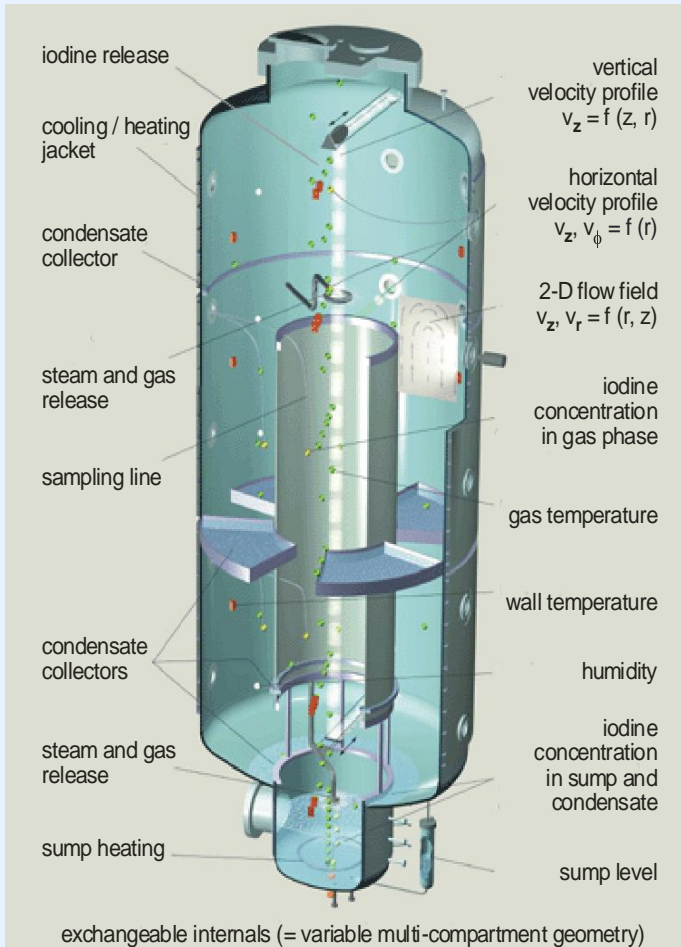
The 60 m³ test vessel is made of 22 mm stainless steel, its height being 9.2 m, its diameter 3.2 m. It can be operated up to 180 °C and 14 bar. The inner multi-compartment geometry is formed by exchangeable steel structures. The vessel is thermally insulat-

ed. Its cylindrical part is equipped with three independent heating/cooling jackets over the height for controlled heating or cooling of the walls by means of an organic liquid. A large top flange and two man holes provide access. Measuring flanges on

five levels at five circumferential positions allow the installation of in-situ optical and conventional instrumentation.

The comprehensive instrumentation covers state of the art and advanced sensors and methods especially for field measurements, in-line gas- and

aerosol diagnostics, on-line and off-line (see figure). Generation and feeding-in techniques for soluble (e.g. CsI) and insoluble (e.g. SnO₂) aerosols and radioactive marked (¹²³I) iodine are applied. Iodine measurements and chemical analysis are supported by the Radiochemical Laboratory of AREVA NP GmbH as engineering service.



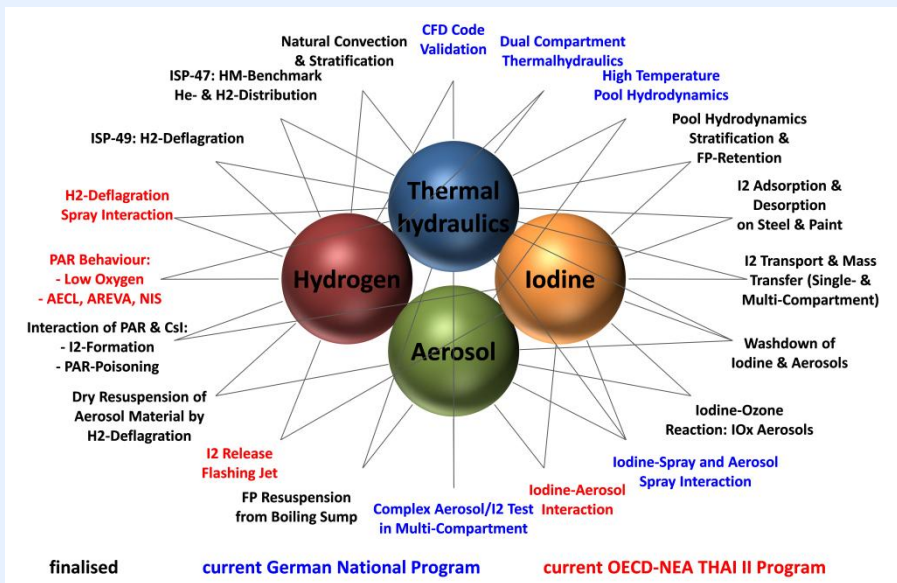
THA vessel and typical instrumentation

THAI - Research Fields (2000 - 2014)

THAI - Test Program since 2000

After construction and commissioning (1998-2000), German National Programs are performed continuously since 2000. The THAI program is executed by Becker Technologies GmbH, Eschborn, in close cooperation with GRS. The acquired experimental data is utilized by numerous German research institutes for code development and code validation. The experimental program itself represents a main element of the German reactor safety research and contributes substantially to sustain knowledge in this field by involving Masters and Ph. D. students either in experimental or analytical activities.

Internationally, a first OECD-NEA THAI Project (2007 - 2009) has been performed in parallel with participants from Canada (COG-AECL), Czech Republic (UJV), Finland (STUK), France (IRSN), Germany (GRS), Hungary (VEIKI), Republic of Korea (KAERI), the Netherlands (VROM) and Switzerland (PSI), focusing on the behaviour of Passive Autocatalytic Recombiners (PARs) under different thermal-hydraulics including interaction with aerosols and iodine, hydrogen deflagration and He/H₂ material scaling tests proving helium being an adequate replacement for hydrogen in experiments.



THAI - Present and Future Activities

A second three years OECD-NEA THAI project has been launched in July 2011 dealing with iodine and iodine/aerosol interaction issues, open questions on hydrogen deflagration, and PAR behaviour related issues.

Participating countries of this OECD-NEA THAI-II project are Canada, Czech Republic, Finland, France, Germany, Hungary, Japan, Republic of Korea, the Netherlands, Sweden and the United Kingdom.

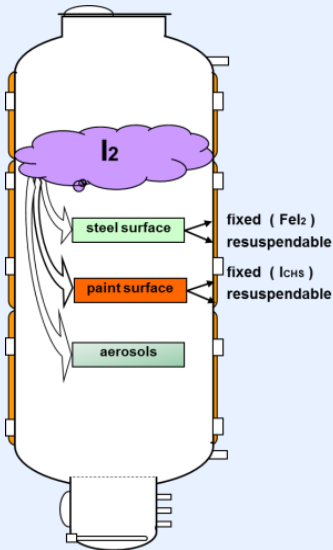
The following experimental matrix is currently being executed in the THAI facility in order to induce safety-relevant improvements such as:

- Release of gaseous iodine from a flashing jet
- Deposition of molecular iodine on aerosol particles
- Hydrogen combustion during spray operation
- Onset of PAR operation in case of extremely low oxygen content

To get along with general increasing standards and hence increasing demands on experimental requirements and instrumentations, Becker Technologies co-operates with national and international research institutes.

Future efforts will focus on data provision to validate and develop simulation programs for “best estimate” predictions of BDBA scenarios. The current national THAI program includes further experimental enhancements to cope with such demands. In this context, it is intended to generate and control two thermal hydraulic atmospheres of different temperature and humidity in order to enable the investigation of flow effects between such two compartments. Fission transport scenarios as well as the investigation of hydrogen and PAR behaviour are planned to be studied within the setup.

Future planning will as well consider containment research needs within the EU and the OECD/NEA, such as e.g. pool scrubbing issues where principal experience has been gained in the course of THAI-BWR experiments.



Examples of international use of THAI data

- **ISP-47, based on THAI TH-13:** Assessment of Lumped Parameter and CFD- Models in the area of containment thermal hydraulics
- **OECD THAI HM-2 Benchmark:** Erosion of a stable atmospheric stratification by means of a buoyant plume, based on the THAI HM-2 test with hydrogen
- **ISP 49:** H₂ combustion (i. a. based on OECD THAI hydrogen deflagration tests)
- **SARNET-1, WP1:** Interpretation of THAI Iod-9 test and code benchmark
- **SARNET-2, WP8:** Benchmark on THAI multi-compartment Iod-11 and Iod-12 tests; Analysis of THAI Iod-13 and Iod-14 tests on iodine/ozone, IO_x-formation and behaviour
- **SARNET2, WP7.3:** Benchmark on THAI PAR-2 and PAR-4 tests to investigate the different PAR modelling strategies
- **German CFD Network** (international): Benchmark on the CFD code validation series TH18-TH24

Reference and Publication List

A reference and publication list is available on request. Additionally to THAI, it covers experience from intermediate- and large scale containment experiments in the former HDR

(Heiß-Dampf-Reaktor) and Battelle Model Containment Facilities, as well as from code development, application and assessment.

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