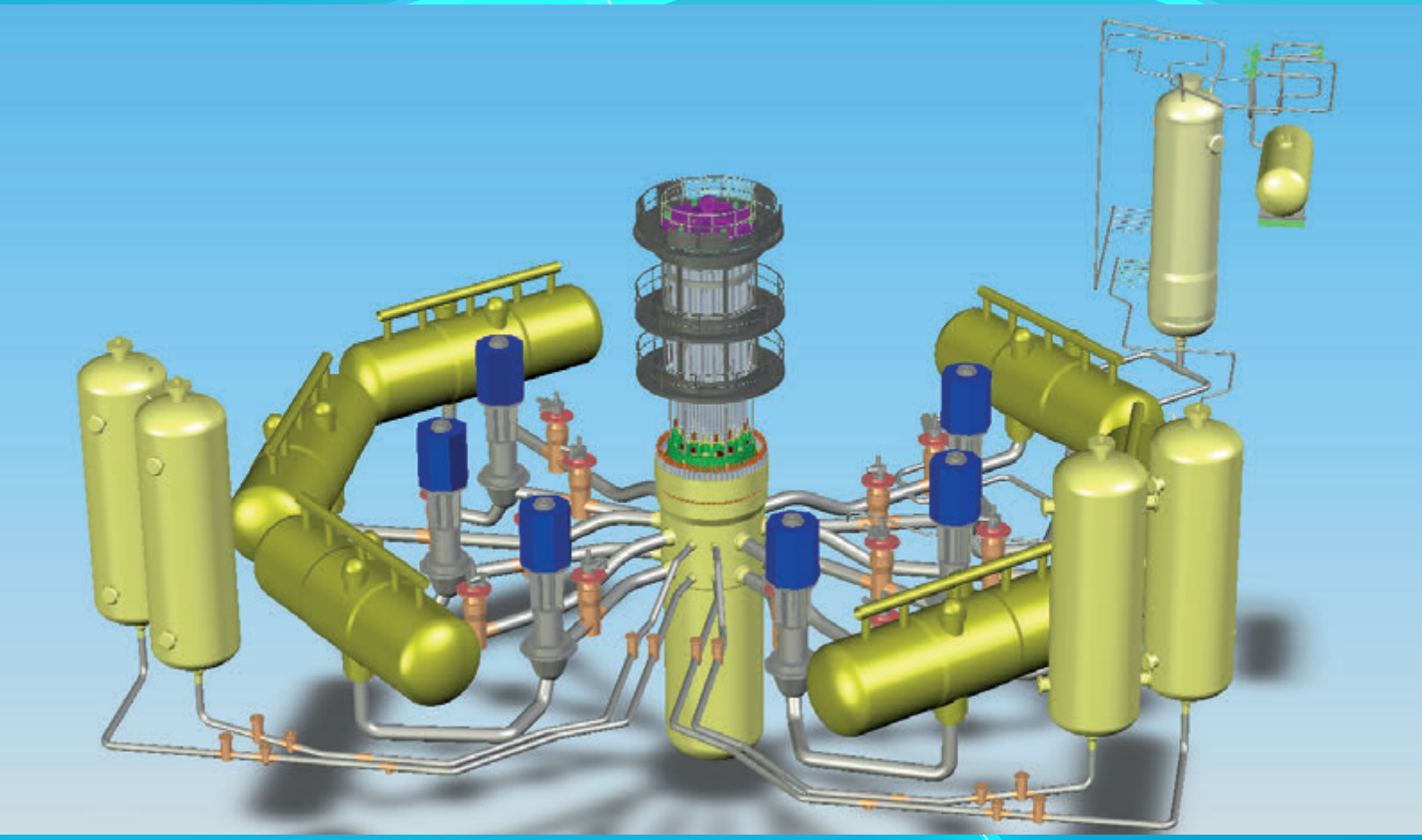
www.tes.eu

TES s.r.o. | Pražská 597 | 674 01 Třebíč | Czech Republic



CALCULATIONS AND SAFETY ANALYSES

- Thermo-hydraulic calculations in NPP
- Accident Management
- Computational safety analyses
- CFD calculations, 3D modelling

As part of its technical support for nuclear power plant (NPP) operators, TES has been actively involved in the conduct of calculations and safety analyses in the long term. Using the most advanced computing resources we are able to accurately model the dynamics of thermal, hydraulic and neutronic processes in nuclear installations. In this field we provide analyses of operational, abnormal and accident conditions in NPPs. In addition, we provide NPP operators with other related services like preparation and evaluation of selected tests using verification pre-test and post-test calculations.

Our nuclear safety support activities integrally include computational safety analyses as well as their independent assessments. Our experts‘ practical experience in the management and operation of nuclear units is hugely advantageous for the development and validation of computational models and subsequently for the performance and evaluation of calculations as well as for the wording of recommendations for NPP operators.

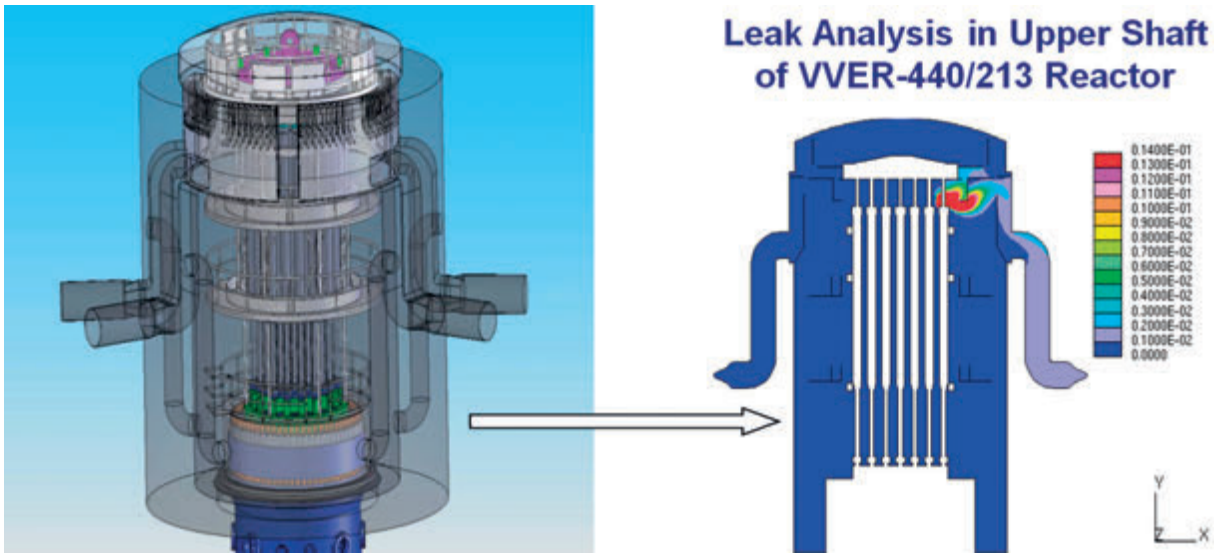
Thermo-hydraulic calculations in NPP

The most frequent analyses in thermo-hydraulics include calculations of operational, abnormal and accident conditions in VVER-440 and VVER-1000 nuclear power plants. The majority of these analyses are carried out by the advanced computational codes RELAP5 or TRACE. In case of severe accidents we use codes MELCOR or MAAP4, while detailed 3D calculations are entrusted to the CFD code ANSYS Fluent.

RELAP5, TRACE and MELCOR have been developed for the purposes of U.S. NRC and have been broadly validated for different types of operational and accident conditions in NPPs. TES uses these programmes as part of its international cooperation efforts in CAMP (Code Applications and Maintenance Program) and in CSARP (Cooperative Severe Accident Research Program), in which TES takes an active part in the future development and independent validation of the computational codes. For computational analyses of nuclear units TES has developed the following comprehensive computational models:

- VVER-1000 nuclear unit (RELAP5, TRACE).
- VVER-440 nuclear unit (RELAP5, TRACE, Fluent).
- PSB-VVER experimental facility (RELAP5, TRACE).
- BC V-213 experimental facility (MELCOR).
- NPP sub-systems and components, such as Temelín NPP spent fuel pool (Fluent, TRACE), VVER-440 containment (MELCOR), VVER-1000 core (PARCS).

All computational models have been broadly validated against the data from real-life incidents in NPPs and from NPP start-up tests as well as against data from tests carried out on experimental facilities.

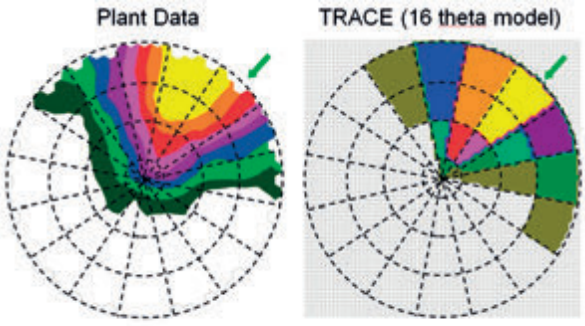


Accident Management

TES experts have gained extensive experience from their long-term activities in the development, validation and implementation of Accident Management (AM) documents for Dukovany and Temelín NPPs. Most computational work supporting AM guidelines was carried out in the system codes RELAP5 and TRACE; our experts have also played a major role in the validation of AM guidelines on full-scale simulators in Dukovany and Temelín NPPs. The typical features of computational validation of AM guidelines include high demands for the set-up of scenarios and simulation of interventions by operational personnel, which also requires considerable practical experience in the management of an actual nuclear unit operation, staff availability as well as determination of the staff response time and handling times for individual actions. In this regard TES draws on the direct experience of its experts, acting as operational personnel in NPPs, in the management of nuclear units. As regards the development, validation and implementation of AM guidelines, we offer the following services:

- Computational analyses for the development and validation of AM guidelines in the following areas.
  - abnormal operation guidelines (AOP),
  - emergency operation guidelines (EOP),
  - severe accident management guidelines (SAMG),
  - manuals (instructions) for the Technical Support Centre (TSC).
- Independent assessment of computational analyses for AM guidelines carried out by other subjects.
- Preparation of the text of and appendices to AM guidelines.
- Cooperation on the validation and evaluation of validation of AM guidelines on a full-scale NPP simulator.
- Calculation and compilation of a comprehensive group of set points for AM guidelines.
- Revisions and re-validations of AM guidelines and set points in connection with NPP modifications (I&C replacement, power up-rate, new type of fuel, etc.).

Computational safety analyses

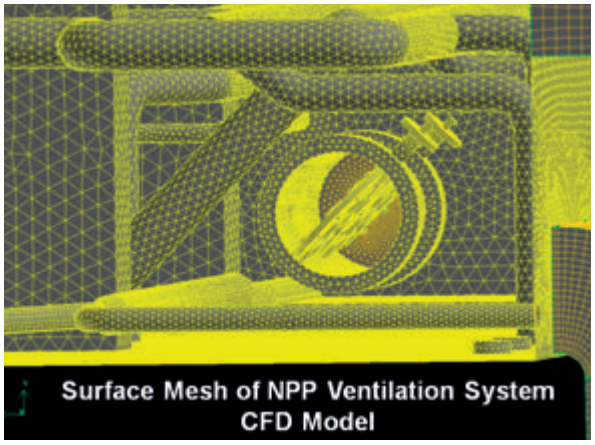


Measured and TRACE calculated Loop1 mixing factors at VVER-440 reactor core outlet

In the long term TES has been involved in the preparation of safety documentation for NPPs as other activities relating to nuclear safety. Our major assets in this respect is the independence of TES of NPP operators as well as national nuclear regulator in the Czech Republic. Computational codes used for safety analyses are subject to specific requirements by nuclear supervision and operators of nuclear installations. For safety calculations in the Czech Republic we therefore use only advanced computational codes, which have been approved by the State Office for Nuclear Safety (SÚJB). In connection with nuclear safety support and preparation of safety documentation we offer the following services:

- Computational safety analyses.
- Independent assessment of computational safety analyses.
- Analyses of incidents in NPPs and analyses of their effects on nuclear safety.
- Expert consultations and reviews for the preparation of safety documentation.
- Preparation of a database of entry data for safety analyses.
- Cooperation on the preparation of selected sections of the Periodic Safety Review (PSR).

CFD calculations


Surface Mesh of NPP Ventilation System CFD Model

Computational Fluid Dynamics (CFD) is a computational method for the detailed modelling of the liquid and gas flow dynamics. It can also include heat and mass transfer, phase changes, chemical reactions, mechanical motion and deformation of solid materials. TES uses the universal CFD code ANSYS containing the broad physical modelling capabilities.

We offer CFD computational analysis for the following areas:

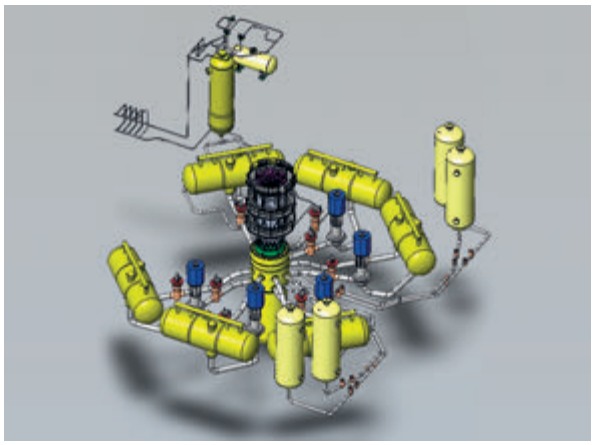
- Nuclear and conventional energy.
- Cooling of power equipment and electronic circuits.
- Environment - releases to the environment, emissions.
- Environmental equipment - cooling, ventilation, heating, air-conditioning.
- Automotive and aerospace industry - internal and external aerodynamics.
- Rotary machines - fans, compressors, turbines, etc.

In nuclear energy we use ANSYS Fluent, in particular in applications with predominant 3D effects. In this case CFD simulations provide data which cannot be usually acquired through measurements on actual technology or through simulations using system codes, such as RELAP5 or TRACE (e.g. for calculations of 3D flows and thermal fields in nuclear reactors or spent fuel pools).

3D modelling

For 3D modelling we use the 3D CAD system SolidWorks. TES has a team of experienced experts who can offer you the following 3D modelling services:

- Custom modelling as per delivered documentation.
- Animation of created 3D models for assembly, presentation and commercial purposes.
- Web presentations of virtual products.
- Customer sharing of 3D models in the eDrawings environment.
- Basic static strength analysis FEM (tension and deformation).
- Preparation of standard 2D drawings based on a finished 3D model.
- Preparation of data sheets.
- Production of geometrical models for CFD flow and thermal process analyses.



- Laser scanning of selected technology (in cooperation with CSA Systems) and subsequent production of a 3D CAD model of the scanned technology.