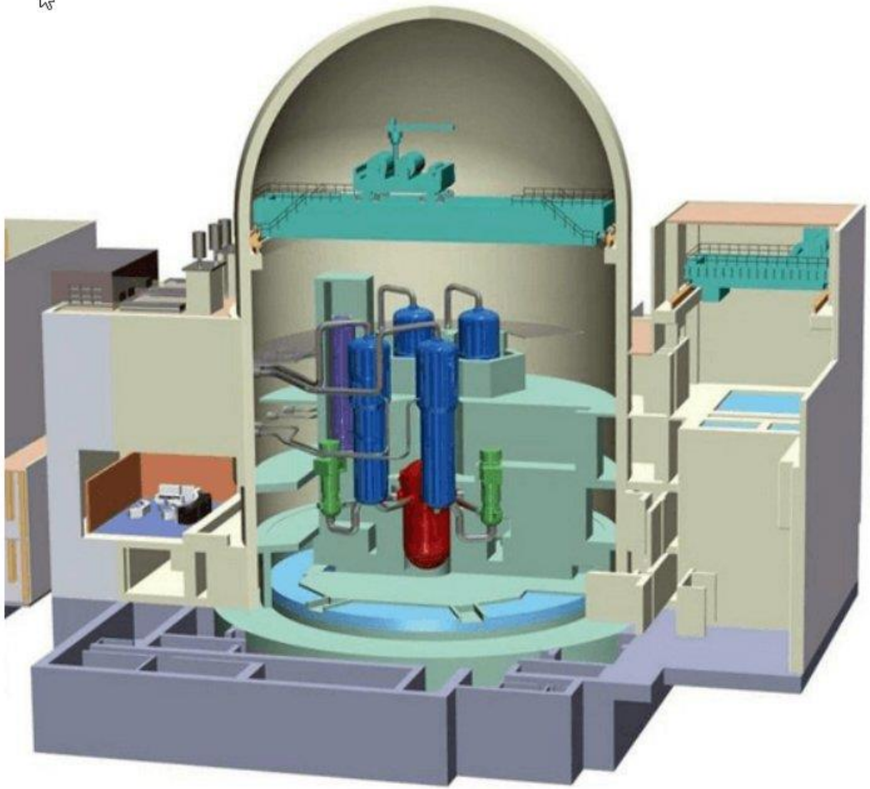

CONTSA : containment safety research

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Objectives

- The 2-year CONTSA project has focused on important containment safety relevant issues and analysis methods to improve their reliability for containment deterministic safety analyses, and hence, to increase containment safety.

- The project relied mainly on the test program of the international OECD/NEA HYMERES-2 co-operation project by using selected tests as comparison cases for code analyses.

- The project followed the results of international OECD/NEA PANDA project and delivered the main findings to SAFIR2022 organisation.
  - The Finland's participation fee for PANDA program was paid through CONTSA.

- The project rounded up containment know-how across relevant research areas such as containment DBA thermal hydraulics, severe accidents and CFD methods.

- The project exchanged knowledge from older to younger experts and educated new experts in the area of containment safety (Master's thesis).

The Panda test facility built and operated by PSI in Switzerland.

Analysing work

- Focused on safety function of two relevant containment safety systems:

  1) multi-nozzle spray systems

  2) containment cooler system (AES-2006 design)

Containment spray tests

- Test arrrangements:

- PANDA spray experiment H2P5 series

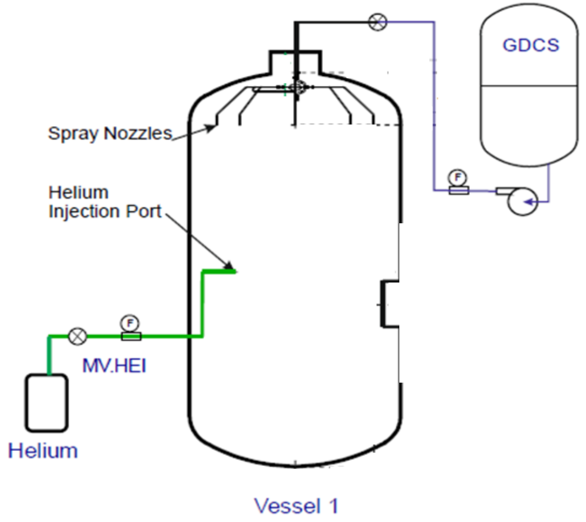
- Vessel height 8 m, diameter 4 m, volume 90 m^3

- Pre-heating with steam injection

- Helium injection created a helium-rich layer in the upper par of the vessel

- Vessel walls were heated to prevents condensation

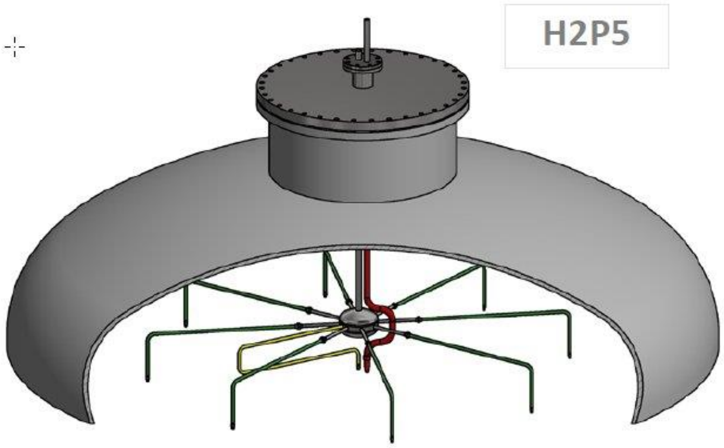
- Compared to one-nozzle test, the multi-nozzle configuration
  - is a more representative nozzle arrangement,
  - produces more uniform gas flow pattern, and
  - produces more significant droplet-wall interaction



Containment spray

Objectives:

- Clarify whether the commonly used containment analysing tools (Apros and MELCOR) are valid for analyses of multi-nozzle spray behaviour

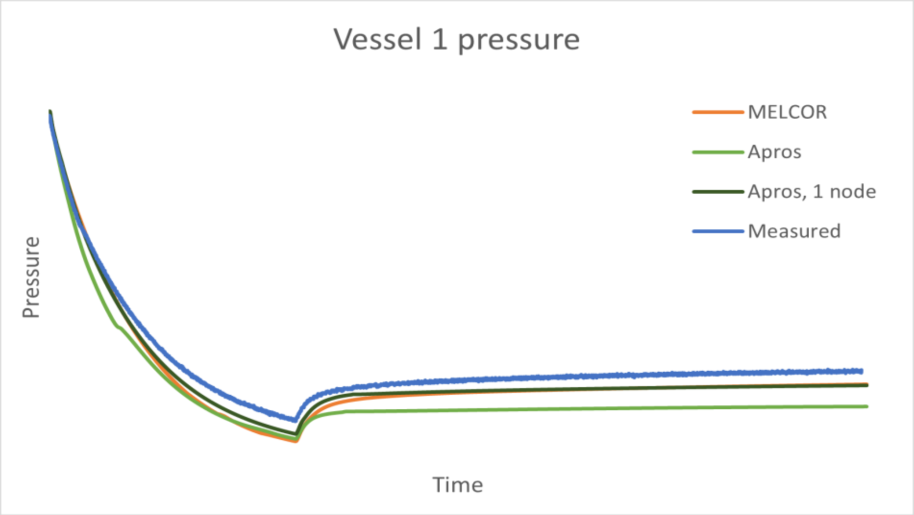


Configuration of 9-nozzle Panda spray test

Containment spray

Main results:

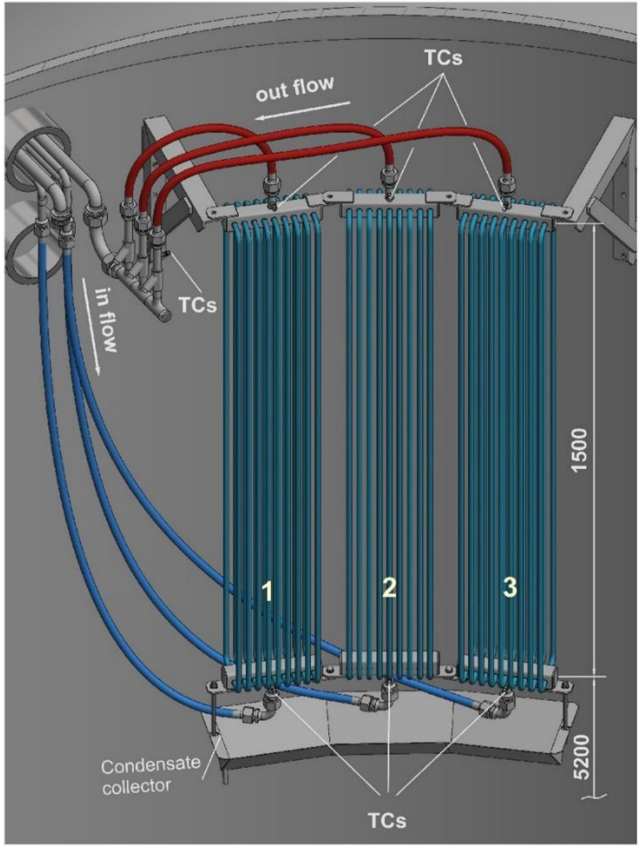
- A part of spray water splashed directly to walls in the multi-nozzle test:
  - had to be taken into account in the calculations
  - cannot be modelled implicitly in the codes
- The codes can model the spray tests reasonably well.
- Tendency to underestimate the pressure
- Besides the cooling by spray, heat transfer from wall to gas and gas natural convection were also important phenomena in these tests.



Containment cooler tests

Test arrangement:

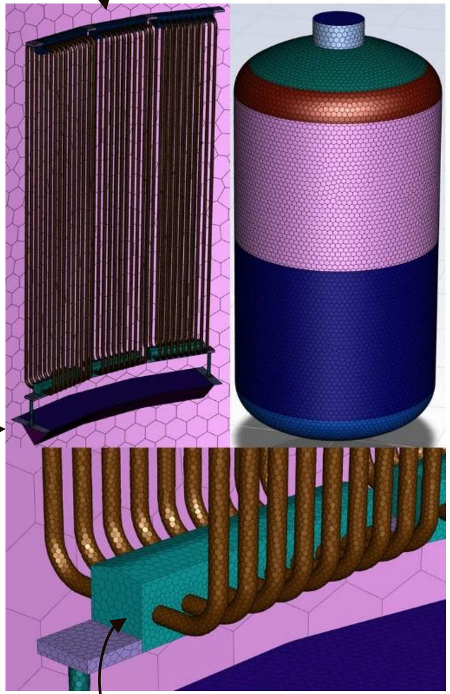
- PANDA cooler experiment H2P6 series
- The cooler resembles the passive containment condenser of the AES-2006 design.
- One and three cooler units arrangements
- Pre-heating with steam injection
- Helium injection creates a helium-rich layer in the upper part of the vessel around the cooler units.



Containment cooler

Objectives:

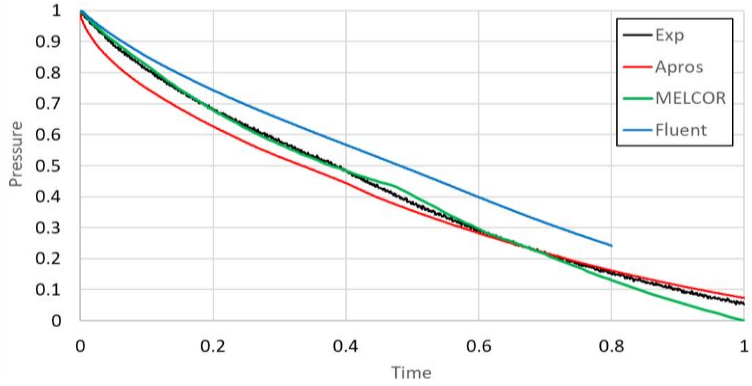
- Study the containment cooler function and modelling capabilities and compare the results of available calculation methods with experimental data
- Comparison between one and three cooler tests
- Analyses with the Apros, MELCOR and CFD Fluent codes

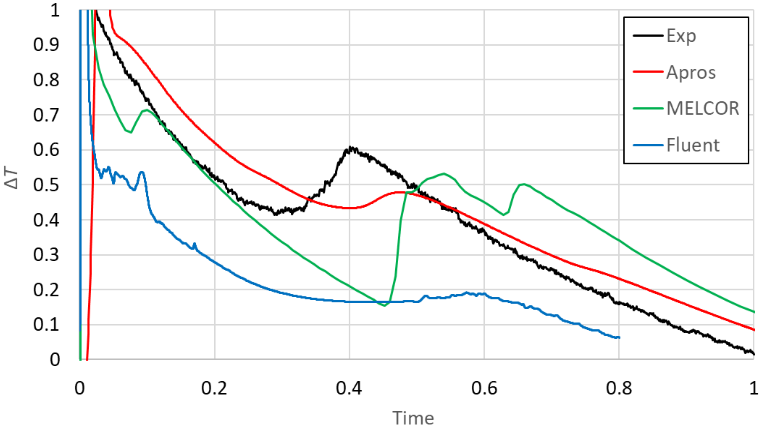


Containment cooler

Main results:

- The experimental containment pressure behaviour was dependent on the cooling power, gas composition, gas stratification/mixing phenomena.
- The initial helium stratification broke at scaled time 0.4 when steam concentration around the cooler units and the cooling power increased momentarily leading to faster pressure decrease.
- In general, all codes could model the pressure behaviour qualitatively reasonably,
- however, quantitative differences between the calculations and measurements were obtained.

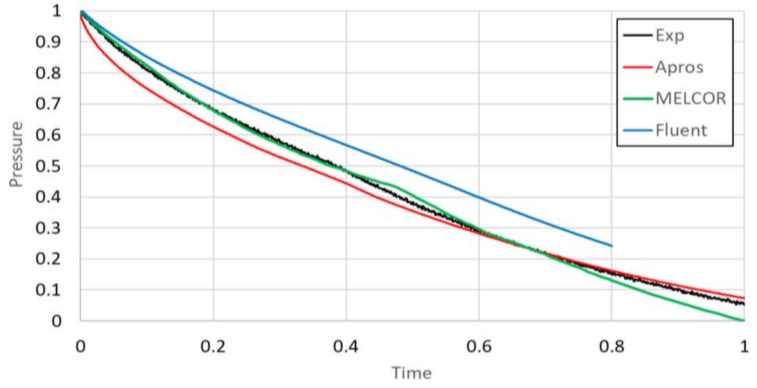


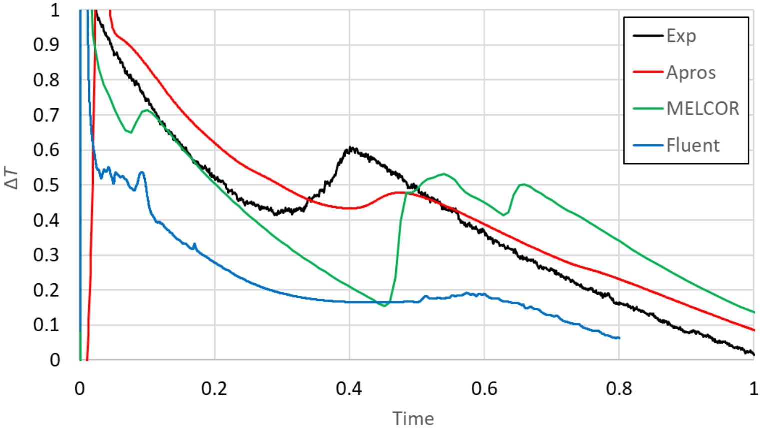


Containment cooler system

Main results:

- Apros and MELCOR codes predicted slightly later break time of gas stratification than in the experiment, Fluent results showed too slow erosion of stratification and too low cooling power throughout the simulation.
- The experimental findings prove that the number of used cooler units is unimportant from the point of cooling efficiency of a single cooler unit, but
- it was not possible to perfectly replicate this characteristics in code analyses.
- This is possibly due to limitations of lumped parameter method in modelling the gas flow pattern correctly that depends on the chosen nodalisation and flow path settings.





Conclusions

VTT

- In general, the containment spraying and cooler system effects could be modelled reasonably well with the analysing methods used.

- Direct splashing of spray water to the walls was of high importance in multi-nozzle spray tests affecting spray cooling power and containment pressure behaviour.

- The cooler induced flow pattern resulted in erosion of gas stratification and enhanced the gas mixing which had influence on the containment depressurization rate.