3.11. DISCO-C - DIspersion of Simulated COrium with Cold fluids

Objectives of the facility

The DISCO-C facility serves to investigate melt dispersal from the reactor pit when the reactor pressure vessel lower head fails at low system pressure of less than 2 MPa. The fluid dynamics of the dispersion process is studied using model fluids, water or bismuth alloy instead of corium, and nitrogen or helium instead of steam. The effects of different breach sizes and locations, and different failure pressures on the dispersion can be studied.

Parameters of the facility

The facility models the reactor pressure vessel (RPV), part of the reactor cooling system (RCS), the cavity, and the pump and steam generator rooms. The length scale is 1:18, compared to a large European reactor.

The pressure vessel consists of a steel pipe with a model of the RPV (outer diameter 298.5 mm) at its lower end. It has a total volume of 0.0879 m^3, that models the volume of the pressure vessel and the volume of part of the RCS. The lower head of the RPV can hold 3.4 ×10-3 m^3 of liquid, which corresponds to 20 m^3 or 160 t of corium.

The cavity, a Plexiglas cylinder with an inner diameter of 342 mm, is attached to the vessel support structure. Generally, the flow path out of the reactor pit is through the annular gap between reactor vessel and cavity wall and along the main cooling lines into the pump and steam generator compartments. There is the option of a flow path through holes straight up into the containment, that is modeled by an extra cylindrical compartment.

The compartments, eight boxes which model in volume the steam generator and pump rooms (0.3 m^3 and 0.131 m^3 each respectively), are connected to the nozzles, and are placed on the vessel support structure around the RPV. They are covered by filters on their tops for the extraction of fog and drops. Two boxes have one Plexiglas wall each, to permit optical access for flow visualization.

The following failure modes of the lower head were studied: central holes and three types of lateral breaches: lateral holes, a horizontal slot, and complete ripping and tilting of the lower head. The horizontal slot models a partial rip in the lower head, as it might occur with a side-peaked heat flux distribution. The flow cross section is equivalent to a 25 mm hole.

The fluids employed were water or a bismuth alloy (similar to Wood's metal) instead of corium, and nitrogen or helium instead of steam. Most experiments were performed for the combination water/nitrogen, with 3.4×10-3 m3 of water. With central holes four hole sizes, 15, 25, 50 and 100 mm diameter (scaled 0.27 m – 1.80 m), were investigated, each at three initial pressures, 0.35, 0.6 and 1.1 MPa. Nitrogen/metal tests were performed with the 25 and the 50-mm-hole at 0.6 and 1.1 MPa with 3.3×10-3 m3 of metal. Some tests (25 and 50 mm hole size) were performed with 1.8×10-3 m3 of water and were repeated several times. The reproducibility was very good.

Instrumentation and measurements

Transient pressures were measured at 30 positions in the vessel, the cavity and the compartments. Although the DISCO-C experiments are not intended to investigate thermal effects, temperatures must be measured because the gas temperature changes during the blowdown and the liquid metal must be heated above the melting temperature of 58°C. Three thermocouples in the pressure vessel and one in the lower cavity measured the gas and liquid temperature. In order to determine velocity profiles across the gap, the Particle Image Velocimetry (PIV) technique was applied in two tests. Also the velocities of the droplets and the liquid jets were determined by PIV behind the nozzle at the entrance to a compartment in a few water tests. Drop sizes could also be established by the digital images taken during the PIV measurements. The mass fraction of the water or liquid metal in the compartments was determined by weighing the boxes before and after the test with a precision scale. The water in the cavity was absorbed in dry cloth, that was weighed. The metal was solid after the test and could be weighed directly.

Two high speed film cameras (LOCAM II, 500 frames/second) were used to record the flow phenomena in the cavity; they were arranged in a view angle of 90 degree to each other. Additionally two CCD-video cameras took pictures from the cavity for a quick view. The liquid flow into two compartments was filmed by a CCD-video camera with 50 frames per second.

The pressure and temperature data were acquired at a sampling rate of 2.5 kHz. 30 channels for pressure and 4 channels for temperature were used. Additionally, signals were recorded from the electro-pneumatic valve (open/closed) and the break wire as a time-zero and sync-signal.

Remarks
The experimental program DISCO-C is finished only for the basic geometry of the EPR. Experiments with other reactor geometries will be performed in the future.

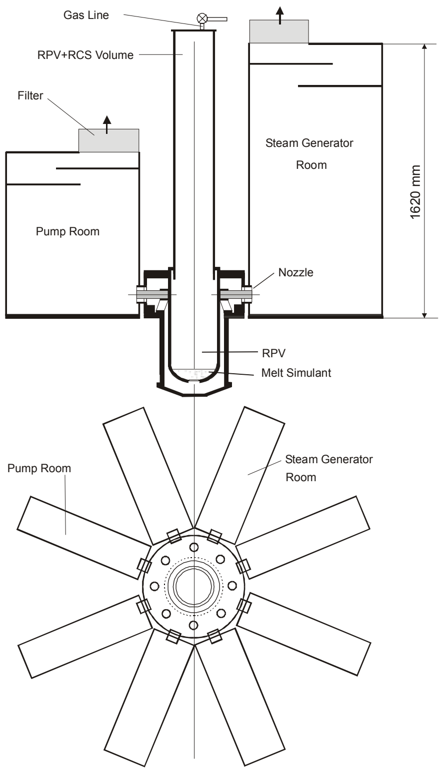

Fig. 11-1 Scheme of DISCO-C facility

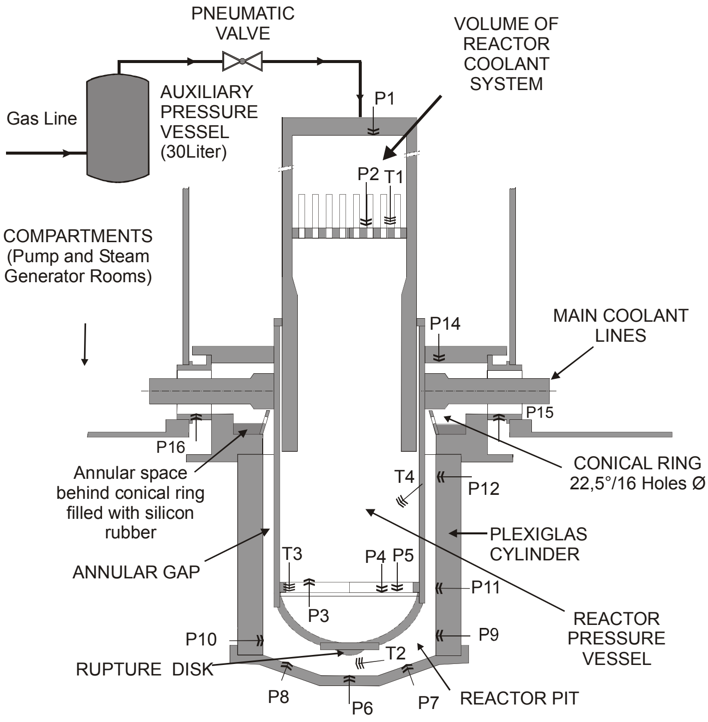

Fig. 11-2 Scheme of DISCO-C Pressure vessel, cavity and instrumentation

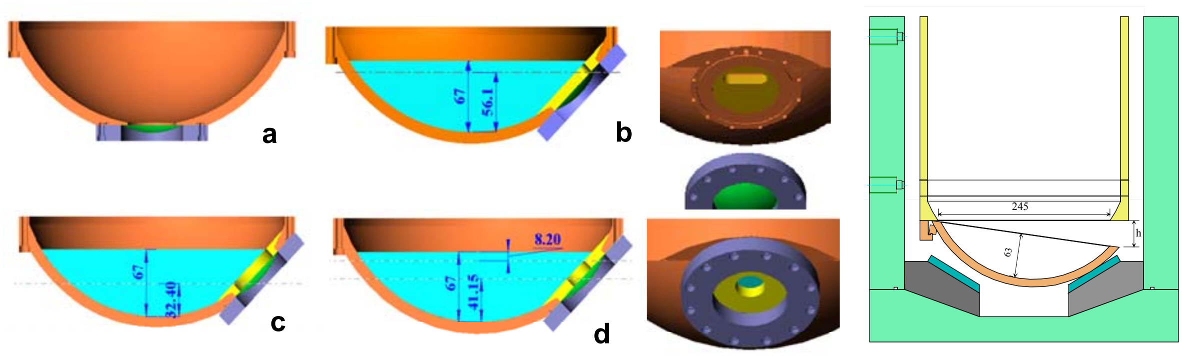

Fig. 11-3 Failure geometries used in DISCO-C

a. Central hole
c. Lateral hole, ∅50 mm
b. Lateral slot, equivalent to ∅25mm
d. Lateral hole, ∅25 mm
e. Unzipping and tilting of the lower head

Table 11.1 DISCO-C Experimental test matrix

Exp. I.D.	Date	Type (Characteristics)
D-04	**11/1999**	3.4 kg water discharged with nitrogen at 0.348 MPa, 25 mm central hole
D-07	**2/2000**	3.4 kg water discharged with nitrogen at 0.620 MPa, 25 mm central hole
D-15	**4/2000**	3.4 kg water discharged with nitrogen at 1.190 MPa, 25 mm central hole
D-06	**2/2000**	3.4 kg water discharged with nitrogen at 0.619 MPa, 50 mm central hole
R-03	**7/2000**	1.8 kg water discharged with nitrogen at 1.10 MPa, 25 mm lateral hole
R-04	**7/2000**	1.8 kg water discharged with nitrogen at 1.10 MPa, 50 mm lateral hole
R-06	**8/2000**	1.8 kg water discharged with nitrogen at 1.61 MPa, 25 mm lateral hole
R-01	**6/2000**	1.8 kg water discharged with nitrogen at 0.61 MPa, 25 mm lateral slot
R-02	**6/2000**	1.8 kg water discharged with nitrogen at 1.10 MPa, 25 mm lateral slot
K-02	**10/2000**	2.1 kg water discharged with nitrogen at 0.80 MPa, unzipping of lower head with drop height of 16 mm
K-04	**12/2000**	2.1 kg water discharged with nitrogen at 0.50 MPa, unzipping of lower head with drop height of 56 mm
M-01	**1/2001**	3.41×10^{-3} m³ liquid metal discharged with nitrogen at 1.045 MPa, 25 mm central hole
M-02	**2/2001**	3.25×10^{-3} m³ liquid metal discharged with nitrogen at 0.595 MPa, 25 mm central hole
M-03	**2/2001**	3.28×10^{-3} m³ liquid metal discharged with nitrogen at 0.582 MPa, 50 mm central hole
M-04	**5/2001**	discharged with nitrogen at 1.000 MPa, 50 mm central hole
R-05	**8/2001**	1.8×10^{-3} m³ liquid metal discharged with nitrogen at 1.05 MPa, 25 mm lateral hole
R-07	**10/2001**	1.8×10^{-3} m³ liquid metal discharged with nitrogen at 1.65 MPa, 25 mm lateral hole
K-03	**12/2001**	2.0×10^{-3} m³ liquid metal discharged with nitrogen at 1.10 MPa, unzipping of lower head with drop height of 16 mm

Status of documentation

EDR	L.Meyer, M.Gargallo, Melt release from RPV, Central holes in the lower head, SAM-ECOSTAR-D01	DelivD01.pdf	1.3 Mb
EDR	L.Meyer, M.Gargallo, Melt release from RPV, Lateral holes in the lower head, SAM-ECOSTAR-D02	DelivD02.pdf	2.6 Mb
EDR	L.Meyer, M.Gargallo, Melt release from RPV, Lateral slots in the lower head, SAM-ECOSTAR-D03	DelivD03.pdf	3.5 Mb
EDR	L.Meyer, M.Gargallo, Melt release from RPV, Unzipping of the lower head, SAM-ECOSTAR-D04	DelivD04.pdf	1.3 Mb
EDR	L.Meyer, M.Gargallo, Melt release from RPV, Experiments with liquid metal and central holes, SAM-ECOSTAR-D05/D06	DelivD05_D06. pdf	2.7 MB
DAT	ASCII and excel files containing all experimental data	*.dat, *.xls	140 Mb