Forschungszentrum Karlsruhe
Technik und Umwelt
Wissenschaftliche Berichte
FZKA 5795

The International Standard Problem ISP37 Calculations with CONTAIN 1.12 for VANAM M3

G. Henneges, H. Peter
Institut für Neutronenphysik und Reaktortechnik
Projekt Nukleare Sicherheitsforschung

Juli 1996

Forschungszentrum Karlsruhe
Technik und Umwelt
Wissenschaftliche Berichte
FZKA 5795

The International Standard Problem ISP37
Calculations with CONTAIN 1.12 for VANAM M3

G. Henneges, H. Peter

Institut für Neutronenphysik und Reaktortechnik
Projekt Nukleare Sicherheitsforschung

Forschungszentrum Karlsruhe GmbH, Karlsruhe
1996

Forschungszentrum Karlsruhe GmbH
Postfach 3640, 76021 Karlsruhe

ISSN 0947-8620

Abstract

This publication deals with results of a series of containment thermalhydraulic and aerosol studies made with the multicompartment code system CONTAIN 1.12 for the VANAM experiment M3. This work was done as a participation to the open ISP37. VANAM M3 was planned to give experimental data for verification of aerosol computer codes and test their thermohydraulic and aerosol results on such a large integral multicompartment containment experiment.

Five different calculations are compared in this paper. The influence of simplifications was studied for example by

- taking only oxygen instead of air as atmospheric gas
- modeling the outer structures only by concrete
- using flow coefficients according to Idel'chick or improved values
- including radiation transport effects.

CONTAIN thermohydraulic results are within the accuracy that can be obtained regarding the uncertainties of the experiment and the the boundary conditions used as code input. CONTAIN is able to simulate atmospheric stratifications as observed in the experiment. VANAM M3 used water soluble NaOH aerosol to study a "dry" aerosol depletion phase and later after a second aerosol injection the behaviour in a "wet" surrounding. The aerosol densities differ by more than an order of magnitude in the different compartments. To calculate this behaviour a multicell code like CONTAIN with its powerful MAEROS tool for the hygroscopic aerosol treatment was needed. The aerosol transport to different cells and the aerosol densities in these rooms are calculated qualitatively correct with CONTAIN 1.12.

Das Internationale Standard Problem ISP37
Rechnungen mit CONTAIN 1.12 für das VANAM M3 Experiment

Zusammenfassung

In diesem Bericht werden die Resultate von thermohydraulischen und Aerosolausbreitungsrechnungen mit dem Programmsystem CONTAIN 1.12 beschrieben, die im Rahmen des Internationalen Standard Problems 37 für das VANAM M3 Experiment durchgeführt wurden. VANAM M3 wurde geplant, um experimentelle Daten zur Verifikation von Aerosolrechenprogrammen in einem großen Mehrraumbehälter zu liefern.

Fünf unterschiedliche Rechnungen werden in diesem Bericht verglichen. Der Einfluß von Simplifizierungen wurde zum Beispiel studiert an

- Rechnungen, wo nur Sauerstoff anstatt Luft in der Atmosphäre benutzt wurde
- Modellierung der äußeren Strukturen durch modifizierte Betonstrukturen
- Benutzung von Flußwiderstandsbeiwerten gemäß Idel'chick bzw. angepaßten Werten
- Berücksichtigung des Strahlungstransporteffekts.

Die mit CONTAIN erhaltenen thermohydraulischen Ergebnisse sind innerhalb der experimentellen Fehler erklärbar durch die Randbedingungen, die den Rechnungen per Eingabe aufgeprägt wurden. Mit CONTAIN gelingt es, die atmosphärische Stratifikation, welche sich im Experiment einstellte, nachzurechnen.
In VANAM M3 wurde das Absetzverhalten von hygroskopischem NaOH Aerosol während einer eher trockenen Phase und nach einer zweiten Injektion während einer nassen Phase untersucht. Die Aerosoldichten unterschieden sich um mehr als eine Größenordnung in den verschiedenen Räumen. Um dieses Verhalten nachzurechnen, war ein Mehrzellenrechenprogramm wie CONTAIN mit seinem leistungsfähigen MAEROS Unterprogramm nötig. CONTAIN 1.12 berechnet sowohl den Transport in die verschiedenen Räume als auch die Aerosoldichten in der richtigen Größenordnung.

The International Standard Problem ISP37
Calculations with CONTAIN 1.12 for VANAM M3

G. Henneges, H. Peter
Forschungszentrum Karlsruhe (FZK)
Institut für Neutronenphysik und Reaktortechnik (INR)

Content

1. Summary

This paper deals with results of a series of containment thermalhydraulic and aerosol studies made with the multicompartment code system CONTAIN 1.12 for the VANAM experiment M3 which was performed at the Battelle Model Containment in Frankfurt. This work was done as a participation to the open OECD/CSNI/ISP-37.

The VANAM M3 test was planned to give experimental data for verification of aerosol computer codes and test their thermohydraulic and aerosol results on such a large integral multicompartment containment experiment.

Five different calculations are compared in this paper. The influence of simplifications was studied for example by

- taking only oxygen instead of air as atmospheric gas
- modeling the outer structures only by concrete
- using flow coefficients according to Idel'chick or improved values
- including radiation transport effects.

Comparing the thermohydraulic CONTAIN results by taking the proposed ISP37-input and compare them with experimental values one may conclude that the calculated pressure is within the accuracy that can be obtained regarding the uncertainties of the boundary conditions. CONTAIN is able to simulate atmospheric stratifications as observed in the experiment.

VANAM M3 used water soluble NaOH aerosol to study a "dry" aerosol depletion phase and later after a second aerosol injection the behaviour in a "wet" surrounding. Although the depletion rate of the very hygroscopic NaOH aerosol depends strongly on the relative humidity (rh) of the atmosphere and on the volume condensation rate at rh = 100% the aerosol behaviour is predicted surprisingly well. The aerosol densities differ by more than an order of magnitude in the different compartments.

To calculate this behaviour a multicell code like CONTAIN with its powerful MAEROS tool for the hygroscopic aerosol treatment was needed. The aerosol transport to different cells is calculated qualitatively correct.

2. Objectives of the ISP37

The ISP37 is an open standard problem, which means that besides initial and boundary conditions, all experimental results are delivered to the participants prior to performing the calculations. These experiments are described in detail in /2/. In the following the subject and objectives of the ISP37 are explained together with the Battelle data and the agreed initial conditions which are neccesary to perform the calculations.

The knowledge on thermalhydraulic long-term effects and depletion behaviour of aerosols in a core melt-down atmosphere of a PWR containment after a LP*-path /4/ is of crucial importance for predicting the environmental impact by the determination of the so-called radioactivity source term.

ISP37 objectives are the comparison and investigation of the following physical variables and phenomena:

- State-of-the-art status review on computer codes for containment analysis with respect to thermalhydraulics and aerosol behaviour

- Phenomena to be investigated

  - behaviour in multi compartment geometry
  - atmospheric mixing by natural convection loops
  - stratified atmosphere
  - structural heat transfer
  - wall condensation
  - saturation ratio, fog formation etc.
  - hygroscopic aerosol distribution and settling
  - volume condensation
  - steam condensation on aerosol component

3. Experiment M3 in the Battelle Model Containment

The model containment is shown in Figure 1. It has a free volume of 626 m^3. The VANAM geometry represents roughly a PWR-containment. The arrangements of the compartments and openings connecting them is shown in Fig. 2 and data is listed in Tables 1 and 2. The concrete and steel structures are shown in Fig. 3 and details are given in Tables 3 to 4. The numbering is sometimes different for the calculations where the rooms 9.1 to 9.4 are grouped in cells 9 to 11 (Fig. 9).

3.1 Measurements

The measured parameters and their accuracy are given in the following Table. The devices, exact locations etc. are described in /2/.

	Error band according to /2/	Comment
temperatures	1.4 K	o.k.
pressure	0.02 bar	o.k.
sump level	0.01 m	sometimes 0.05m
humidity	10 %	when the sensor is wet due to condensate, the signal is greater than 100 %
gas velocity	0.15 m/s	a minimum velocity of 0.2 m/s is necessary to initiate turbine flow meter measurement
steam injection rate to R5	0.01 kg/s	measurement device not redundant
steam injection rate to R3	0.006 kg/s	measurement device not redundant
air injection	0.6 l/s	measurement device not redundant
air removal	0.3 g/s	measurement device not redundant

3.2 Experimental Phases

The experiment is oriented on the core meltdown scenarion LP* according to the German Risk Study, Phase B /4/. First steam is injected into room R5. This simulates the blowdown of the primary circuit. After a phase without injection, steam is injected into the lower part of the model containment (R3) corresponding to the contact of corium and sump water.

This scenario leads to the following 6 experimental phases (see Fig. 4 and Tab. 5 to 8):

Phase 1: 1.13 to 17.2h (4068 to 61920s)

The containment is heated up and the initial boundary conditions are adjusted by injection of steam in R5. This injection is controlled to get a constant containment pressure of 1.25 bar in all rooms. At the beginning of this phase air is removed out of R9.4. This allows steam to enter the lower compartments and heat up the structures. At the end of phase 1 (from 16.52 to 16.61h) air is reinjected into R9.4 (cell 10) and R3 to get the desired air content.

Phase 2: 17.2 to 18.23h (61920 to 65628s)

Hygroscopic NaOH aerosol is injected in R5. It is suspended in a steam-air mixture. No pressure control is done. Therefore the presssure rises to 2.05 bar.

Phase 3: 18.23 to 22.7h (65628 to 81720s)

All injections are stopped. Because the steam condensation on the colder structures is not compensated the pressure decreases to 1.25 bar.

Phase 4: 22.7 to 23.14h (81720 to 83304s)

NaOH suspended in a steam-air mixture is injected a second time into R5. The pressure increases again.

Phase 5: 23.14 to 25.26h (83304 to 90936s)

For the first 600s all injections are stopped. Then steam is injected into the lower central room R3. The pressure increases to 1.7 bar.

Phase 6: 25.26 to 30.0h (90936 to 108000s)

The steam is now injected into R5. The pressure stabilizes near 1.7 bar.

3.3 Summary of Thermohydraulic Results

Some of the measured results are shown in Fig. 5 (flow velocities) and 6 (temperatures in room 9). Fig. 7 gives information of the locations for the heights of the thermocouples used in the outer ring cell and the dome. The abbreviations used indicate heights above zero level and location angle in the cylinder.

When steam or steam-air mixture is injected to R5 a convection loop mixes the atmosphere of the upper inner rooms (R5, R7) and the dome (R9d) according to Fig. 5. As a result of the mixing the temperatures in these rooms are nearly identical. The atmosphere in the lower inner compartments R1, R3, R6 and R8 generally stagnates. In the bottom closed annulus (R9.3, R9.4 and R4) it always stagnates.

At about 4h the steam front reaches the elevation of the openings of R1, enters it and replaces air. A weak convection loop between R5 and R6 removes air out of R6, R8 and R1. The convection lasts until 10h.

When steam is injected to R3 in phase 5 a strong convection loop is induced, which mixes all inner rooms. When the steam injection is switched to R5 the stagnation in the lower inner rooms is reestablished.

The annulus (R9.3 + R9.4) and R4 always stays stratified. For better illustration of the temperature evolution in rooms 9.3, 9.4 and 9d (dome) the measured values are given in Fig. 6. The heights of the thermocouples are depicted as well. The rotational symmetry is not perfect. A single temperature value for rooms 9.3, 9.4 and the dome is difficult to deduce. Therefore a comparison with calculated numbers is only qualitatively possible (see chapter 7.2). This problem holds for rooms 4,6 and 8 as well.

3.4 Summary of Aerosol Results

The measured histories for the aerosol concentrations are depicted in Fig. 8. As mentioned earlier at the end of phase 1 the containment atmosphere is stratified with mainly hot steam in the upper part and cold air in the lower part.

In phase 2 the aerosol is injected into R5. By the natural convection loop R5 > R9d > R7 the NaOH is distributed. Due to the rising pressure aerosol loaded atmosphere flows from the upper rooms to the lower rooms, as well as into the annular rooms. The condensation on the cold structures of these rooms increases the downward flows.

In phase 3 all injections are stopped. The dome R9d, R5 and R7 have equal aerosol concentrations. These are in the beginning significantly higher than in the other rooms.

In phase 4 with its second aerosol injection the flow conditions are comparable to those of phase 2.

In the mixing phase 5 when steam is injected to the central lower room R3 one has to distinguish two different flow patterns: At the beginning, the steam mainly heats up the lower rooms R3, R6 and R8 by condensation on the cold structures. The pressure rises slightly which induces a small atmospheric flow from the lower to the upper rooms. Because of the short duration the spatial aerosol distribution is not much affected. Then the flows change rapidly. A large natural convection loop establishes from R3 to the dome and mixes the whole inner containment. All these rooms have now the same aerosol concentration. The aerosol concentrations decrease rapidly in all rooms except the annulus due to strong volume condensation.

In phase 6 steam injection is moved back to R5 which yields comparable flows like those in phase 2. The aerosol concentration in the annular rooms is in the beginning 100 times higher than in the other rooms.

3.5 Vapour Condensation on the NaOH Aerosol

The depletion rate of the very hygroscopic NaOH aerosol depends strongly on the relative humidity (rh) of the atmosphere and the volume condensation rate at rh = 100%.

Tab. 9 gives information on the local humidity histories. The black bars indicate time and location of larger amounts of airborne water (fog). The atmosphere was saturated and volume condensation occured. The white bars show measured superheated conditions with rh < 100%.

In phase 2 in nearly all rooms fog formation takes place. In phase 3 the atmosphere of the whole containment is superheated with lowest humidities at the end of this phase (about 85% in the upper rooms but around 100% in the others). During this phase the aerosol particles grow by the hygroscopic water take-up and aerosol depletion occurs under rather dry conditions.

In the mixing phase 5 extensive volume condensation takes place in all rooms except in the annular rooms. Because of the wet conditions the aerosols deplete rapidly.

4. Specifications for Modelling ISP37

This chapter repeats some of the specifications given in /1/ and describes the different approach which was sometimes necessary to complete the calculations.

4.1 Geometry, nodes, connections, flowpath and structures

The nodalisation has been reduced to a minimum number of 11 cells. This was thought to be sufficient to simulate all important phenomena measured in the experiment. It should be reasonable easy to handle for combined thermalhydraulic and aerosol calculations.

The sumps on the bottom of some cells had to be modelled code according to the code used. This could be as individual nodes or as it is done in CONTAIN /3/ by specifying them as lower cells.

The atmospheric flow paths are specified according to Tab. 2a,b and shown in Fig. 9. In /1/ it is proposed to use flow coefficients based on Tab. 2b.

They are higher than the values derived by taking Idel'chicks method for unrecoverable pressure loss. The influence of different flow coefficients was studied. More informations are given in chapters 5 and 7.

The containment structures are shown in Fig. 3. The informations of Tab. 3b from /1/ are used to deduce the values for the code input. Slabs with average cross sectional areas are used. The coating of internal surfaces of the outer containment shell should be simulated. The coating of the inner containment walls could be neglected. In total 50 structures are defined. Except structures 1 to 8 and 46, they are modelled by only one material.

The properties of structures of the outer shell are given in Tab. 3c. A correct description of the outer shell was used in the calulations of case 44, case 45 and case 46. Case 40 and case 42 used the 'simulant concrete'. The latter calculations only took concrete and steel materials as they are 'hardwired' in CONTAIN.

The proposed material properties according to /1/ are given in Tab. 4. Besides the default data for heavy concrete of CONTAIN case 44, case 45 and case 46 calculations used the data given in Tab. 4.

The aerosol deposition areas for each room are subdivided in floor, ceiling and vertical walls. The orientations are given in Tab. 3a and 3b.

4.2 Initial and Boundary Conditions

The initial and boundary temperatures are shown in Tab. 5. All structures of the outer shell have a uniform temperature of 295K at the beginning of the experiment.

The building which is in contact to the model containment according to Fig. 3 and 9) has a constant temperature of 295K, the environment is kept at 283K equal to the soil temperature.

Steam injection rates into cells R5 and R3 are listed in Tab. 6. The controlled air removal and injections in and from cells R9.4, R3 and R5 are shown in Tab. 7a,b.

4.3 Leakage

The model containment has a high atmospheric leakage through small cracks and fissures in the walls. The leakrates had been determined experimentally by using the actual air content and the known air injections and removals. They were given as an input to all participants (see Tab. 8a). The leakrate had to be split in a way proposed by /1/ but this approach led to problems. Later it was agreed to split the leakage in different rooms as shown in Tab. 8b,c.

The steam condensation inside the walls is an obstruction to the leak flow. The condensate will not block the leak path totally. Part of it will penetrate the wall, transporting its energy (saturated water). It is estimated in /1/ that at the start of the experiment 2% and at the end 10% of the steam, entering a crack, could reach the environment. But the steam leakage was not measured and therefore it was proposed not to take it into account. This may lead to a 0.2 to 0.3 bar higher calculated pressure.

4.4 Aerosol Data

The NaOH aerosol injection data are given in Tab. 10. The injection values for the aerosol carrier gas (air and steam) are listed in Tab. 6. The aerosol mass injection rates are constant for both injection periods.

The particle size distribution was estimated using electron microscop pictures. A log-normal distribution of the particle sizes was assumed. For the primary NaOH-aerosol distribution the following values are recommended:

Log-normal distribution	
Mass median diameter	MMD = 0.2e-6 m
Geometric standard deviation	GSD = 1.9 --> ln1.9 = 0.641854

The effective density of the dry primary NaOH-particles is not known. The theoretical density of pure NaOH is 2130 kg/m^3. In the wet atmosphere the hygroscopic salt increases its diameter rapidly and the effective particle density decreases. A mean value of 1100 kg/m^3 is proposed for the calculations.

Since the humidities are always near 100% during the experiment a Van't Hoff factor under these conditions of SOL = 2.0 is recommended. Because the aerosol particles rapidly become spherical droplets the dynamic and agglomeration shape factors CHI and GAMMA are 1.0.

5. CONTAIN Calculations

Each CONTAIN calculation discussed in this paper used the same nodalisation scheme. Fig. 9 shows the atmospheric and Fig. 10 the drain flow pathes used. 11 nodes (cells) are simulating the containment. The values of Tab. 1 are taken. The upper and lower node boundaries are used to determine the cell center heights.

In five cells sumps are modelled. The sump floor areas of Tab. 1 are used. In cells 5 and 7 no sumps are modelled because condensed water was diverted to cells 6 or 10 respectively. Condensed water from cell 11 was directed to the sump of cell 10 which is different from the proposed split in /1/ because in CONTAIN only one cell can be specified to take the condensate from a donor cell. Therefore 100% of the condensate is forced to drain to cell 10 (R9.4) as shown in Fig. 10.

(According to the proposal it should be diverted from dome R9d to
R9.3 (56.2%) + R7 (4.4%) + R2 (31.4%) +
R5 (3.5%) + R4 (4.5%)).

The volume of the environment (cell 12) is very large (1.0e15 m^3).

There are 13 atmospheric junctions for gas flow. The input values of Tables 2a,b are used. The **flow coefficients** of both tables are halfed according to the models used in CONTAIN (see chapter A.2). The Idel'chick values which are given in Tab. 2a were used for case 40, case 42 and case 44 calculations. The aerosol calculations case 45 and case 46 used the flow coefficients of Tab. 2b which are larger. They are based on experience with earlier Battelle containment calculations and their derivation is explained in more detail in /1/. By comparing the thermohydraulic results with those of case 44 one clearly observes the influenc of this parameter (see chapter 7).

6 drain junctions are modelled according to Fig. 10. Atmospheric flow through these junctions is not possible. As mentioned earlier the condensation from the dome (cell 11) to lower cells is modified. 18 outer and 32 inner structures are definded.

Each internal **structure** between different cells is modelled by two 'half slabs' with a very high heat transfer coefficient between them (HGAP = 1.0e20 W/m^2K). This value is a recommended user input if this option is taken. It was used for each internal structure (concrete and steel). The internal structures in rooms 1 to 8 and 11 are at the beginning at 25°C. R9.3 and R9.4 are at 22°C. Only the structures 17 to 22 have therefore a temperature step-function with the warmer surface 1 at 25°C and the colder surface 2 at 22°C. The structures of the outer shell (1 to 16) all have the same temperature of 22°C (building).

The **temperature profiles** at the beginning of the calculation are user input. The variable TUNIF for all structures was specified which gives a uniform initial temperature for the whole structure (each node center has the same TUNIF value).

Calculated temperature profiles for inner and outer structures 2 and 18 are shown in Fig. 14 and 15 for different cases, each at about 10h (36018s) and at 30h (108000s). The results are discussed in chapter 7.5.

The **heat transfer** between the outer containment surfaces and the neighbouring structures or environment has nearly no influence because of the short experimental time. Therefore only the heat transfer coefficient between the outer containment and the environment (cell 12) is modelled due to the different temperatures of the building and environment. These temperatures are user input.

This means that the outer shell structures of Table 3b have all the initial building temperature of 22°C. This was done because of the relatively thick concrete structures and the dominance of the building temperature. Only structure 47 (rupture disk in top cover is 1cm steel) is at 10°C which is environment temperature.

In most calculations the recommended CONTAIN option CONDENSE was used. It means the following: The **surface condensation model** for all structures in the cell and for the lower cell pool is activated. The default maximum condensate film depth is 0.5mm. There was no change possible contrary to the input description (FLMAX). Any excess condensate will drain to a lower cell which can be specified by the OVERFLOW-option. This is done according to the recommended drain flow path scheme (Fig. 10). No forced convection input table was used.

If CONDENSE is not specified heat transfer between the atmosphere and structures is modelled with a dry convective heat transfer coefficient of 6.08 W/m^2K.

If DROPOUT is specified all suspended liquid coolant from the atmosphere is removed and deposited in the appropriate pool. This is only possible if no aerosols are present (e.g. steam). This model was used only for one case to see the influence on pressure and temperature. The difference was very small for these variables but large for saturation ratio.

Due to the low temperatures **no radiation** was modelled for runs case 40 to case 45. Because Siccama reported at the second ISP37 workshop (2/96) that including it had a strong effect on the aerosol behaviour in phase 5 one additional calculation (case 46) with RAD-HEAT=on was performed. The results are discussed in chapters 5.4 and 7.10.

No additional **boundary specifications** were used (e.g. adiabatic).

The **watermass** at the end of 3 calculations is given in Table 11 to check the water balance of injected steam versus the sum of the distributed water.

Two typical CONTAIN input files are given in Tab. 13 (case 42) and Tab. 14 (case 46).

5.1 Simplifications for Case 40 and Case 42

There were situations where the calculation stopped or did not converge or gave questionable results. Therefore the input complexity for the outer shell structures input was reduced. Because of the relatively short experiment (30h) it was believed that the heat would not penetrate the relatively thick outer shell.

In both calculations the thickness of structures 1 to 8 and 46 of the outer shell is calculated from the values given in Table 3c and 4 by multiplying the material thickness of material X in Table 4 with the ratio of heat conductivity of reinforced concrete divided by heat conductivity of material X. For example material YTONG has heat conductivity 0.55W/mK and concrete 2.4W/mK. A ratio = 4.36 is deduced which means that the thickness of YTONG in the outer shell structures is multiplied by 4.36. But this outer structure description has the disadvantage not to take into account the different heat capacities of the materials shown in Tab. 4. That means the structure temperatures for node 1 could be o.k. but definetely not the node temperatures of the outer nodes.

Additionally, the modelling of air leakages out of different cells and the injections/removals of air or vapor in parallel caused many problems to the code. This was overcome by reducing the CONTAIN input complexity even more for case 40:

The number of input tables was minimized in cells 3,4,5,10 and 11 by taking **only oxygen** in the cell atmospheres instead of air (0.79 molfraction N2 plus 0.21 O2). Because the density of air (1.2928kg/m^3) is 1.105 times smaller than that of oxygen (1.4289kg/m^3) the air mass flow rates in **case 40** were divided by this value. The free atmospheric volumes in each cell was reduced by this factor as well to have the total oxygen mass comparable with the air mass given in /1/. The leakage- and air injection mass tables are modified accordingly (Tab. 8b and 7a).

This approach has to be seen historically. After most of the difficulties with CONTAIN were solved the complexity of case 40 was increased and the calculation repeated with air (case 42).

5.2 Air Leakage

It is not known from which rooms the air leaks out. A good approach was thought to let the air leak out of cells 3,4,10 and 11. The leak rates are shown in Tab. 8b,c. It is taken as stepfunction input table. From 1.13h to 2.74h 25% of air leaks out of cell 11 and 75% out of cells 3,4 and 10. The 75% leakage is volume weighted for these 3 cells. From 2.74h to 14.75h only cells 3,4,10 leak air. From 14.75h to 30h the leakage is modelled as in the first phase with 25% from cell 11 and 75% coming from cells 3,4 and 10. Steam leakage was small (< 5%) and not taken into account for ISP37.

5.3 Aerosols

For the thermalhydraulic calculations case 40 to 44 the only aerosol modelled is steam. The number of aerosol particle sections is 10. The volume equivalent mass median particle diameter for the initial distribution is 1.0e-8 m and the natural logarithm of geometric standard deviation of the particle size for the initial distribution is 0.405.

If NaOH is included as a second aerosol with the numbers proposed in Appendix B of /1/ the CONTAIN calculation stops with error message 'problems in dynamp' after some thousand seconds depending on the time step size and other parameters.

This problem could be solved by the following input modifications:

- do not specify SURTEN = 73.0e-3
- specify 'better' diam1, diam2, tgas1, tgas2, pgas1, pgas2 values which are shown in Tab. 14
- increase TIMINC to 2.0s after restart time 54068s till 74068s

5.4 Radiative Heat Transfer

As mentioned earlier, due to the low temperatures no radiation was modelled for the first runs (case 40 to case 45). Because Siccama reported at the second ISP37 workshop (2/96) that including it had a strong effect on the aerosol behaviour in phase 5 one additional calculation (case 46) with RAD-HEAT=ON was performed. The results are discussed in chapter 7. The rad-heat block was specified with the recommended emissivity value for water vapour (0.94 in each cell) because the value for wet NaOH was not known. The default Modak model is used for gas emittance. By specifying KMX=1.0 the aerosol mass concentrations calculated by CONTAIN are made proportional to the absorption coefficient. For small soot-like aerosols and a material density of 2000kg/m^3 KMX is about 1.0 /3/. For comparison reasons with Siccama results this value was taken as well. A geometric mean beam length GASWAL of 2.5 was used which again is is the value Siccama used. It activates the simple atmosphere to structure radiation model and is used for all structures and the uppermost lower cell layer. More information to the radiation treatment in CONTAIN is summarized in A.10. The input file for case 46 is given in Tab. 14.

6. Information to Computer Environment

The CONTAIN 1.12 Version /3/ with update C110W for use on workstations was used. It was distributed in Sept. 1994 to FZK. All calculations were run on IBM RISC 6000/370 workstation. Optimisation to level 2 of the F77 compiler gave equal results as those calculated with 1.12 Version on the IBM main frame computer M3090 and is therefore believed reliable. Higher optimisation to compiler level 3 gave wrong results for aerosols and fission product calculations if the code is not modified.

CONTAIN calculations stop if the timestep size is too coarse. The time intervalls had to be reduced to values of 1.0s which means that the CPU-time is large. Changing the steep slopes of material injections or removals was necessary. For air-leakage only changes from linear interpolation to step functions of the input tables solved convergence problems.

The computing time for the ISP37-problem depended strongly on the time step sizes: They varied between 10000s CPU-time for coarse calculations and more than 100000s for finest timesteps! This is for thermohydraulic calculations alone with vapor included. The calculations discussed in this paper used internal time step sizes of 1.0s which led to a CPU-time of about 10h.

The aerosol calculations (case 45 and 46) made many problems if the 'moving grid scheme' was used. This is necessary when the hygroscopic behaviour of NaOH is calculated (SOLUBL = on). Then the calculation stopped around 60000s. A restart at 54068s with a coarser timestep of 2.0s for the next 20000s did work. With 'RAD-HEAT = on' the case 46 calculation could not be finished. It stopped around 90000s and increasing (Δt up to 10s) or decreasing (Δt down to 0.1s) did not solve the problem.

No modifications are done to the code.

7. Discussion of the Analytical Results

The differences of the discussed CONTAIN calculations are summarized in Tab. 12. The calculations submitted to the ISP37 comparision in 10/95 are cases 40 and 42. Both differ only in the composition of the atmospheric gas, which is pure O_2 for case 40 and air(0.79 N_2 + 0.21 O_2 molefractions) for case 42. They used the flux coefficients of Tab. 2b from /3/ which are based on Idel'chick evaluations and have both the simplified outer structures described in chapter 5.1. To separate the effect of only O_2 versus air in the atmosphere is possible by comparing case 40 with 42.

The influence of the correct modelling of the outer structures can be studied by comparing the results of cases 42 with 44.

Which are the correct flux coefficients - those of Tab. 2a or Tab. 2b in /1/ is not easy to answer. Therefore with both sets calculations were made.

The CONTAIN calculation case 45 is identical with 44 but with NaOH aerosols included. No radiative heat transfer is modelled.

This effect of radiation heat transfer is studied in case 46 where the simplified GASWAL block is activated additionally.

7.1 Pressure

The measured pressure in the dome (cell 11) is shown in Fig. 4. Calculated values and the influence of the above mentioned input modifications can be seen in Fig. 11 to 13.

Fig. 11 shows the influence of the simplification O2 vrs. air. Case 40 with only oxygen gives up to 0.1bar higher pressures. The peak value is identical for both cases.

Comparing case 42 with 44 shows the influence of the correct modelling of the outer structures (Fig. 12). The simplification reduced the p-values by about 0.05bar in phase 1 and phase 6. For phase 2 to 5 they are nearly identical.

Fig. 13 gives the pressure evolutions for cases 44 and 45 and for better comparison the experimental values as well. These calculations use different flux coefficients. The difference on pressure evolution is very small (< 0.02 bar) till 27h. Then it increases to 0.2 bar at 30h. Case 44 stays closer to the experiment ($\Delta p < 0.1$bar). It differs in the heat up phase by only 0.1bar from the experiment; for the other phases the agreement is even better.

The differences in pressure evolution can be qualitatively explained if the structure surface temperatures are examined (chapter 7.5).

7.2 Temperatures

The measured and calculated temperatures are shown in Fig. 16 to 18. The opaque symbols which are connected by solid lines indicate the calculated results for case 45. The filled symbols and dashed lines are the related experimental values. The plots are grouped according to cell locations (heights) and the measured temperatures. The calculated temperatures for the other cases differ only by some degrees. Case 45 is taken as reference because it is the aerosol calculation.

The calculated and measured temperatures of the upper cells 2,5,9 and 11 are shown in Fig. 16. It can be seen that after about 15h the measured temperatures of cells 5,9 and 11 are nearly the same (108°C) and of cell 2 is slightly lower (98°C). Till the end of phase 1 (17.2h) the temperatures drop in each of these cells. Due to the air/steam injection in phase 2 (till 18.23h) the temperatures increase by about 10°C. They drop in phase 3(till 22.7h) by about 15°C. In phase 4(till 23.14h) follows again a temperature rise of some degrees because steam/air is injected a second time in cell 5. After a short stop of all injections (10min) steam is injected into the lower room 3. This causes again a temperature rise in the cells till 25.26h. In phase 6 the steam injection is switched back to cell 5 till the end of the experiment (30h). This induces additional temperature increase.

The calculations for cell 5 slightly overpredict the temperatures in phase 1 by up to 4°C but in phase 2 the difference increase to more than 10°C. Phase 3 to 6 is much better calculated with only small differences. The differences for cell 11 are generally larger. Phase 4 has the largest difference of about 20°C. For both cells the shape of the curves is well predicted. The calculation for cell 9 shows no larger temperature differences than those for cells 5 and 11 but the shape differs more from the experimental plot. This is even more obvious for cell 2 where the calculated curve differs between 20 and 50°C and the shape is very different. One possible explaination for this large C-E difference is the necessary modification of the actual drain flow path split to cell 2 which could not be taken into account by the calculation. This split of the condensate steam from cell 11 should have been 31.4% for cell 2. The calculations instead assumed 100% flow to cell 10 (Fig. 10).

The temperatures of the lower inner cells 1,3,6 and 8 are given in Fig. 17. The measured temperatures are lower and clearly show stratification. Comparing the calculated with the experimental results leads to the following observation: the general shape for cell 1 is similar but the calculation overpredicts the measured values after 7h by about 20°C. The agreement for cell 3 is much better with C-E values near 10°C and smaller. During the heat up phase till 17h CONTAIN overpredicts the temperature by up to 20°C for cell 6. The following period is very well calculated with C-E being smaller than 5°C. Cell 8 shows comparable behaviour. But during phase 1 the C-E reaches 40°C at 8h. In phase 2 C-E decreases to about 10°C. The next phases 3 to 5 give smaller differences. At 30h CONTAIN calculates a 15°C higher temperature than measured.

The temperatures of the outer ring cells 9,10 and 4 are depicted in Fig. 18. The temperatures again show stratification. For better comparison the temperatures of cell 9 are included. The agreement for cell 10 is very good with C-E differences being smaller than 10°C. Cell 4 is badly situated in the model containment to be simulated with a lumped parameter code. Connections and heat transfers are difficult to be modeled correctly. It is not surprising that the steep temperature increase (till 8h) which is calculated is not found for the experiment where the maximal value is reached 6 hours later. But than the differences stay below 20°C and the general shape is comparable.

Due to the measured inner cell stratification in cells 4,6,8,9 and 10 one should only qualitatively compare the numbers with calculations because CONTAIN assumes for each node a well mixed atmosphere. Which experimental temperature curve at which time has to be taken for comparison is difficult to decide (see Fig. 6 and chapter 3.3).

But taking all calculated results one may conclude that the overall trend is well predicted in most cells, especially in those nodes where major aerosol effects take place (nodes 3,5,9,10 and 11). Though the subdivision was coarse in z-direction the stratification is qualitatively correct calculated by CONTAIN.

7.3 Atmospheric Flow Velocities

The measured and calculated flux velocities for case 42 are shown for 3 connections:

- from cell 5 to cell 11 in Fig. 19
- from cell 7 to cell 11 in Fig. 20
- from cell 7 to cell 8 in Fig. 21.

It is obvious that calculations and measurements in Fig. 19 and 20 agree quite well (a minimum velocity of 0.2 m/s is necessary to initiate turbine flow meter measurement - the error band is then 0.15 m/s. With the flow meter used no flow direction was measured. The calculations give this information as well). But for phases 4 and 5 (22.7 to 25.3h) CONTAIN calculates a flow velocity of 0.5 m/s and a reversal of flow direction for flux 7 to 8 as is shown in Fig. 21. This is in contradiction to the experiment where no flow velocity is measured at that time intervall.

7.4 Structure Temperatures

The temperature profiles at the beginning of the calculation are user input. The variable TUNIF for all structures was specified which gives a uniform initial temperature for the whole structure (each node center has the same TUNIF value). Calculated temperature profiles for outer structures 2 and inner structure 18 are shown in Fig. 14 and 15, each at about 10h (36018s) and at 30h(108000s).

The surface temperature differences between case 42 and 44 (Fig. 14 and 15) help to understand the pressure differences discussed in chapter 7.1. Structure 2 is located in cell 9 and part of the outer shell. It was chosen as an example of the outer structures which were modelled differently in cases

40,42 and 44 to 46. TUNIF was 22°C. The sharp increase of the temperature of structure 2 near the surface for case 44 results from the coating material. It has a much stronger influence on the thermal hydraulics than expected and should therefore not be neglected. The insulation effect of the air gap at 45 cm depth is well shown.

The simplifications made for cases 40 and 42 give too small structure temperatures at the outer surfaces because the coating was not modeled by the proposed method (see chapter 5.1). This leads to lower pressure values which only apparantly agrees better with the experiment.

Fig. 15 shows as an example the temperature profile of an inner structure which is positioned half in cell 6 (left) and half in cell 10. At the beginning of the calculation cell 6 was at 25°C and cell 10 at 22°C. The modeling of inner structures was the same for each of t he calculations. The shape of each temperature profile (case 40 and 42) is similar and is typical also for the other cases calculated.

7.5 Air Mass

The total air and vapor masses calculated by CONTAIN are shown in Fig. 22 for case 42 which stands for cases 44,45 and 46 as well. The total air mass has to be compared with the numbers determined by the experimentalists. For better comparison its profile is given in Fig. 23 (taken from /1/, page 61). The agreement for total air mass is very good.

7.6 Water and Vapour Mass

The water and vapor masses at the end of 3 calculations are given in Table 11 to check the water balance of injected steam versus the sum of the distributed water. The differences between the calculations are small. The sum of the total injected steam mass agrees well with the calculated values. The evolution of the total vapor mass for case 42 is shown in Fig. 22.

7.7 Sump Temperatures

The sump temperatures are generally overestimated in the calculation because the split of the condensate in cell 11 does not agree with the experimental drain flow path (Fig. 10). This can be seen in Fig. 24 where the measured and calculated sump temperatures are shown as a matter of completeness.

7.8 Saturation Ratios (Humidities)

The detected fog and measured humidities are given in Tab. 9 for phases 2 to 6 for selected rooms and different heights in room 9. With the coarse nodalisation of ISP37 one is not able to calculate at the four given positions the humidities. The values at position R9 (1.0m) should represent cell 10, the mean of R9 (3.6m) and R9 (6.0m) refers to cell 9 and the mean of R9 (7.6m) and R9 (6.0m) represent cell 11. R1, R3, R5, R6, R7 and R8 refer to cells 1,3,5,6,7 and 8. The heat up phase is not shown. During the aerosol injection of phase 2 in most of the cells fog formation (rh = 100%) is detected. Then the injection is stopped and for about 4.5h superheated (dry) conditions are found. In this dry surroundings the aerosol settling is measured (phase 3). The second injection of aerosols (phase 4) is followed by the mixing phase 5. This gives "wet" conditions in each of the cells. During phase 5 and 6 aerosol depletion in wet surroundings can be studied.

Some calculated results are shown in Fig. 25 for cells 5,8,9 and 11 and compared with experimental relative humidities. CONTAIN calculates a saturation ratio which is defined as the ratio of the total mass of coolant (liquid plus vapor) present in the atmosphere to the amount that would be present if the gas temperature corresponded to the dew point, with all other conditions held fixed. Thus, values of saturation ratio less than one represent a superheated condition, while values greater than one represent saturated conditions with suspended liquid coolant. Liquid water on aerosols is not included in this ratio.

To compare the experimental results with the calculated values the given humidities were divided by 100. But then values larger than one are derived. This is not easy to understand. If one accepts that those measured values are equal to one and the calculated saturation rates larger than one are defined to be 1.0 some remarks are possible:

- for cell 9 the C-E difference is very large (10 to 40%) at each time
- for cell 5 the C-E difference is large (30%) between 19 to 24h
- for cell 8 the agreement is very good besides of phase 4 (around 23h)
- for cell 11 the agreement again is good, but not from 26.2 to 27h.

Due to difficulties in measuring rh near 100% with higher accuracy (see chapter 3.1) than 10% the reader is asked to compare the calculated saturation values shown in Fig. 25 with the experimental values of Tab. 9 because the rhs shown there are only qualitative numbers.

7.9 NaOH Aerosol Concentrations (RADHEAT = off)

The experimental aerosol concentrations are given together with case 45 results in Fig. 26 to 28. The aerosol depletion is very well calculated for the dome (cell 11). Shape and absolute values agree quite well. The accuracy of the measurements are in the order of 1.e-06 kg/m^3 as is illustrated by the scatter of the last 3 measured values.

The NaOH-aerosol diameter increases rapidly (Fig. 30) because of its hygroscopy. This leads to very fast depletion of the aerosol particles - two orders of magnitude in about two hours! CONTAIN calculates conservatively smaller depletion rates in phase 3 (50%). The results of phase 4 are reproduced even better.

Fig. 27 shows the results for cell 9. This cell is located in the upper outer ring of the containment. Due to this location only 18% of the maximal aerosol concentration measured in the dome are reached. The depletion is again in qualitative agreement with the experiment. The calculated highest concentrations are of the same order. The decrease in phase 3 is underpredicted by CONTAIN by at least a factor of 20. This again could be the result of the poor splitting of the condensate drain flow from cell 11. Cell 9 should get 56% of this condensate but in the calculations it is diverted directly to cell 10.

Fig. 28 summarizes the measured and calculated NaOH concentrations in the lowest located cell 3. Only a small amount of the injected aerosol reaches this part of the model containment. The maximum experimental concentration is less than 2% compared to the initial dome concentration. CONTAIN calculates a much higher transport to cell 3 (14%). The measured decrease of the aerosol concentration in phase 3 is nearly two orders of magnitude while the code calculates only one order. The calculated concentration after the second injection is overpredicted by a factor of ten. The shape of the depletion for this phase is comparable with the experimental one.

7.10 NaOH Aerosol Concentrations (RADHEAT = on)

The influence of radiative heat transfer (RADHEAT = on) is shown in Fig. 29. Cases 45 and 46 results are compared. The CONTAIN calculation with RADHEAT on stopped after about 25h with negative radii of the aerosol particles. The comparison of both calculations show that during dry conditions (phase 3 and 4) results in cells 9 and 11 are nearly identical. The concentrations in cell 3 are smaller if radiation heat transfer is allowed by up to a factor of three but the shape is similar. The difference increases strongly for the time after the second aerosol injection (wet conditions). With radiation heat on the decrease of the aerosol concentration is extremly faster than for case 45. This is in contradiction to the observed values.

These differences are reflected also when the mass median diameters are compared. In cell 3 the radiation effect leads to higher aerosol diameters which results in much smaller aerosol concentrations. There is nearly no difference for cells 9 and 11 till 23h neither for aerosol mean diameters nor for aerosol densities. For cell 9 the radiation effect leads to slightly smaller diameters with only minor effects on the aerosol densities. It is much larger for cells 3 and 11 where the diameters are calculated higher by factors of up to 3.

8. Conclusions

This report presents results of a series of containment thermalhydraulic and aerosol studies made with the multicompartment code system CONTAIN 1.12 for the VANAM experiment M3 which was performed at the Battelle Model Containment in Frankfurt. This work was done as a participation to the open international standard problem OECD/CSNI/ISP-37.

The VANAM M3 test was planned to give experimental data for verification of aerosol computer codes and test their thermohydraulic and aerosol results on such a large integral multicompartment containment experiment.

Five different calculations are compared in this paper. The influence of simplifications was studied for example by

- taking only oxygen instead of air as atmospheric gas
- modeling the outer structures only by concrete
- using flow coefficients according to Idel'chick or improved values
- including radiation transport effects.

The calculated pressure is within the accuracy that can be obtained regarding the uncertainties of the boundary conditions. CONTAIN is able to simulate atmospheric stratifications as observed in the experiment. Due to the coarse nodalisation the observed stratification inside of some rooms cannot be calculated because the lumped parameter code CONTAIN assumes that the atmosphere in these rooms is well mixed. A higher subdivision would certainly result in a better prediction of the observed stratification.

VANAM M3 used water soluble NaOH aerosol to study a "dry" aerosol depletion phase and later after a second aerosol injection the behaviour in a "wet" environment. Although the depletion rate of the hygroscopic NaOH aerosol depends strongly on the relative humidity (rh) of the atmosphere and the volume condensation rate at rh = 100% the aerosol behaviour is predicted surprisingly well. The aerosol densities differ by more than an order of magnitude in the different compartments. Therefore one needs a multicell code like CONTAIN with its highly developped aerosol routines which include hygroscopic aerosol treatment. Additionally, the aerosol transport to different cells is calculated qualitatively correct.

A sensitivity calculation with respect to the effect of radiation heat transfer shows that a simple description of this effect has a strong influence on aerosol concentrations during bulk condensation in a wet environment.This is in contradiction to the experiment and has to be studied in future.

Appendix: Theoretical Models used in CONTAIN 1.12

CONTAIN treats a containment system as a network of interconnected compartments (cells or nodes). Gas flow, liquid flow and/or heat flow is possible between them. For computational purposes, each cell/node is divided into two subcells: an upper and a lower cell. The upper cell consists of the gaseous atmosphere and the heat transfer structures that are in contact with it. The lower cell can include a coolant pool, the concrete floor etc. The lower cell models are optional, some cells may consist only of the atmosphere and the structures.

A.1 Cell Atmosphere

The cell atmosphere model treats the atmosphere thermodynamics, condensation and evaporation, heat transfer to structures, aerosol behaviour, the intercell flow of gases and aerosols, etc. The atmosphere treament is zero dimensional, i.e. the atmosphere is considered to be thoroughly mixed. Where a pool is modelled, it can be a significant source of gases, aerosols and thermal energy injected to the atmosphere in that node. The structures in the compartment may be treated as thermal sources or sinks. Material can be added or removed via the interconnecting flow paths, by lower cell models, or by user specified source tables.

Variables of state (such as temperature, pressure and enthalpy) are calculated according to equilibrium thermodynamics. External heat sources and sinks, as well as coolant phase changes, are taken into account. Sources to the atmosphere include heat transfer from structures, mass and energy from the lower cell, flows into the cell from other cells, and user-defined sources.

The condensation onto or evaporation from structure surfaces is modelled. It can occur simultaneously with condensation and evaporation on/from aerosols. The aerosol treatment includes models of three agglomeration processes: Brownian, gravitational and turbulant. In addition four deposition processes are considered: gravitational settling, diffusiophoresis, thermophoresis and particle diffusion.

A.2 Intercompartment Flow

Atmospheric flow between cells is modelled as user-specified or pressure driven orifice flow. The user specifies either the flow rate or the geometry of the flow paths between interconnected pairs of cells. The material transferred through the path is a portion of the atmosphere of the upstream compartment. Additionally engineering vents allow to model more than the above mentioned flow-paths between cells. Besides that the user may define additionally engineering vents. No mass or energy is considered to be in a flow path at a given time, and no losses of mass or energy occur in flow paths or vents.

Two simple treatments of the liquid portion of the atmosphere condensable material inventory are available: the default treatment leaves the liquid in the atmosphere (e.g. as steam) to flow with the gas and to contribute to its heat capacity; the alternative (dropout) specifies that any such liquid is instantaneously removed from the atmosphere of a cell and placed in the pool of that cell, if present. Of course, the most accurate treatment lies between these extremes. For ISP37 both types of calculations resulted in nearly identical pressure and temperature values.

There are different ways to calculate the flow in a flow path: it can be calculated from the pressure difference across the flow path in a manner that considers the inertia of the material in the flow path as well as the frictional flow resistance of the flow path itself. Alternatively, the flow may be set to a user-specified mass flow rate or a volumetric flow rate independent of the pressure difference (for further details see /1/, pages 2-13ff). Both models are used. Please notice, that CONTAIN defines flow coefficients differently from /1/. They are half of the values given in Tab. 2a/b of /1/. Details are given in /3/, pages 2-13 ff.

A.3 Lower Cell and Sump Models

The lower cell system of models differs from the upper cell system primarily in that it deals with liquid and solid layers, as opposed to a gaseous atmosphere. The lower cell may include a concrete layer, intermediate layers and a coolant pool layer. Above an atmosphere layer has to follow. The lower cell is treated like a coupled thermal system, with heat transfer coefficients between layers. Coolant can condense or evaporate from the surface.

In the calculations done for ISP37 the lower cells in nodes 3,4,6,8 and 10 consist of a system of nodalized concrete (5 layers), a coolant pool (1 layer), and the atmosphere layer. Each layer is thermally coupled to adjacent layers by interlayer heat transfer coefficients which are by default internally calculated. The atmosphere layer serves merely as a collector of mass and energy which are generated by other layers and are to be passed to the upper cell.

The boiling model is activated in each of the calculations considered here which means that the pool is taken thermally coupled to the other lower cell nodes; however, any energy that would rise the pool above saturation is kept separate and passed to a seperate routine to determine the boiling rate. This energy is determined by iteration if the conduction routine returns a pool temperature above saturation temperature.

The draining of coolant from the atmosphere is modelled for all the calculations. The condense option is used. Then the coolant component is added to the condensate film on the deposition surface. If this film becomes too thick the excess coolant runs off to the pool in a specified overflow cell. Condensation heat is transferred to the pool. The Nusselt number on the atmosphere side of the atmosphere-pool interface is calculated as if the pool were a floor structure with a characteristic length equal to the pool diameter and a 'wall' temperature equal to the bulk pool temperature. The pool surface temperature is calculated self-consistently from the heat flux into the pool. Heat transfer coefficients and correlations are those described in /3/, pages 2-106 ff. and are not modified.

A.4 Drainage Simulation

When the condensate film thickness reaches a maximum thickness, any additional condensate is considered to drain from the structure surfaces and to flow into the pool of the cell specified by the overflow keyword. As shown in Fig. 10 the condensate of cell 1 flows to the sump of cell 3, 2 to 8, 7 to 8, 9 to 10, 5 to 6 and 11 to 10. The last is different to the proposed splitting into cells 9,7,2,5 and 4. This cannot be modelled in CONTAIN. Only one cell may be specified to take the overflow.

A.5 Boundaries

The inner boundary of a structure is always inside the cell in which the structure is defined and exchanges heat with the atmosphere through condensation, evaporation or radiation.. From 7 possible outer boundary conditions mentioned in /3/ two are used: (1) uniform temperature condition at the beginning and (2) the structure is connected to the outer boundary of a structure in another cell.

A.6 Material Properties

The properties of concrete, steam, water, oxygen and steel were taken from the internal libraries of CONTAIN /3/.

A.7 Heat Transfer Model

The heat transfer from the containment atmosphere to the structures and the sump surfaces takes convection, condensation and evaporation into account. No radiation effects are treated for ISP37, because the temperatures are so low that its influence is thought to be negligible. For case 46 radiation was included. Its influence is discussed in A.10.

Heat transfer within each structure is handled by solving a one-dimensional heat conduction equation for the materials specified for the structure.

CONTAIN allows for planar, cylindrical or spherical geometries. Planar is used here as proposed in /1/. The type of orientation of the structure may be either a roof, wall or floor. Different heat transfer correlations are used with respect to aerosol deposition.

Structures may have two surfaces designated as inner and outer. The inner surface is always inside the cell and exchanges heat with the atmosphere through convective heat transfer and through condensation and evaporation of coolant. The code calculates a forced convective velocity for each structure surface from flow path velocities. Convection and condensation models are described in detail in /3/ pages 2-66 ff. for the upper cell and in pages 2-106 ff. for the lower cell.

A.8 Coupling of Atmosphere and Water, Fog Formation

Under saturated conditions steam and water in a node would be in thermal equilibrium. They have saturation temperature. If temperature changes, either water evaporates or steam condenses in order to conserve the equilibrium. CONTAIN calculates the saturation ratio as the ratio of the total mass of coolant (liquid plus vapour) present in the atmosphere to the amount that would be present if the gas temperature corresponded to the dew point, with all other conditions held fixed. Thus, values of the saturation ratio less than one represent a superheated condition, while values greater than one represent saturated conditions with suspended liquid coolant. Liquid water on aerosols is not included in this ratio.

A.9 Aerosol Treatment

The MAEROS aerosol model forms the basis for CONTAIN aerosol models in either wet or dry environments. The model uses a number NSECTN of size classes, to represent the particle size distribution for the suspended aerosols. One may specify up to 8 aerosol components. CONTAIN tracks the composition of a particle as a function of particle size according to the agglomeration and condensation history of the particle. Condensed water can be one of the aerosol components; the condensation and evaporation of water vapour, as they affect the aerosol composition and size, are modelled. The size distribution parameters govern the initial distribution and the distribution of sizes in a source of new particles. CONTAIN needs AMEAN and AVAR values to run a aerosol calculation. AMEAN is the volume-equivalent mass median diameter and AVAR is the natural logarithm of the geometric standard deviation with respect to diameter.

The lower and upper diameters for the particle sizes considered in the calculation are given by DIAM1 and DIAM2, respectively. The calculation of the coefficients is somewhat costly. Therefore they are either read from a file or calculated on the first call to the aerosol model for use throughout the entire problem. Using a constant set of coefficients imposes some modeling constraints:

- The aerosol material density is assumed to be the same for all components.
- The particle shape is independent of the particle composition.
- The medium in which the aerosol processes are assumed to occur has fixed composition and is taken to be air.

A fixed set of aerosol coefficients can only be defined for a given temperature and pressure interval. However, the aerosol module actually calculates four sets of coefficients at points given by combinations of two temperatures (TGAS1 and TGAS2) and two pressures (PGAS1 and PGAS2). Changing thermal-hydraulic conditions during the problem are accommodated by interpolating between these sets of coefficients. These values should be chosen to bound the temperatures and pressures expected.

The ordinary differential equations governing agglomeration, deposition and condensation on aerosols are integrated forward in time using a Runge-Kutta method with its own timestep control. These three effects are assumed to occur in a closed cell during the integration, and changes in the aerosol population due to intercell flow are incorporated separately at every system timestep.

Two methods are available for computing aerosol dynamics with respect to condensation or evaporation of water to or from aerosol particles. These methods are the fixed- and moving-grid methods. The solubility effect of hygroscopic NaOH can only be calculated with the moving-grid method. This method is taken if SOLAER (soluble aerosol) is included in the input. The algorithm used is based on the method of characteristics and permits aerosol of the same size to be of different chemical composition during the condensation calculation. However, after the effects of condensation are calculated over a system timestep, the aerosol is remapped onto the fixed grid used for coagulation and deposition calculations. Thus, after the aerosol calculations are completed for a time step, all particles in a section have the same composition. For each timestep the growth or evaporation of a group of particles is calculated based on the assumed steam concentration at the end of the timestep. The water mass balance is determined from the amount of water condensed or vaporized and the assumed steam concentration. The code iterates on the end-of-timestep steam concentration until the water mass balance is satisfied.

Aerosols are allowed to flow between cells through regular flow paths and engineered vents. Deposition within such flow paths is not modelled.

A.10 Aerosol Treatment with Respect to Radiation

If temperatures are high the heat transfer is affected by the large quantities of water vapour that are present in a containment after a PWR core melt accident. Aerosols contribute to the scattering and absorptivity of the atmosphere and therefore their effects should also be considered in the radiative process. CONTAIN allows through the RAD-HEAT input block to calculate radiative heat transfer within a cell by two different methods.

The simpler GASWAL model was used which only treats the radiative heat transfer between the atmosphere and the structures in the cell and between the uppermost lower cell layer. The net enclosure method (ENCLOS) self-consistently treats the direct radiative heat transfer among all structures and the lower cell. Both models make use of the gas radiation properties that account for the absorptivity of aerosols and the emissivity of vapour. The default Modak model is used for gas emittance. The RAD-HEAT block was specified with the recommended emissivity value for water vapour (0.94 in each cell) because the value for wet NaOH was not known.

By specifying KMX = 1.0 the aerosol mass concentrations calculated by CONTAIN are made proportional to the absorption coefficient. For small soot-like aerosols and a material density of 2000kg/m^3 KMX is about 1.0. If NaOH aerosols are small and soot-like is not known. Nevertheless 1.0 was taken.

A geometric mean beam length of 2.5 was used. It activates the simple atmosphere - to - structure radiation model and is used for all structures and the uppermost lower cell layer. This describes the fact that usually the enclosure is gray and not black, which means that some of the radiation striking it is reflected back into the gas and to other parts of the enclosure. Multiplication of the net radiative heat transfer flux q between the gas-aerosol mixture at gas temperature Tg and a black enclosure at temperature Tw by the surface emissivity, allows for proper reduction of the primary beams (gas - to -surface or surface - to - gas). With the user supplied EMSVT and GASWAL values the gas absorptivities are calculated from the Modak model by using Kirchhoff's law of radiation.

The input file for case 46 (RAD-HEAT = ON) is given in Tab. 14.

9. Literature

/1/ M. Firnhaber, S. Schwarz, G. Weber, "Specification of the International Standard Problem ISP 37," GRS, Köln, April 1995

/2/ T. Kanzleiter, "VANAM-Mehrraum-Aerosolabbau-Versuch M3 mit löslichem Aerosolmaterial," Techn. Fachber. BleV-R67.098-304, Battelle Frankfurt, Juli 1993

/3/ K. K. Murata et. al., "Users Manual for CONTAIN 1.1," NUREG/CR-5026, Sandia National Laboratory (1989)

/4/ "Deutsche Risikostudie Kernkraftwerke, Phase B", GRS-A-1600, Juni 1989, GRS Köln

10. Tables

Table 1a: Volumes, node centers and sump floor area (case 40)

Cell /1/	CONT	Volume(m^3)	Node center(m)	Sump floor area(m^2)
R1	01	14.48*	2.3	0
R2	02	23.53*	4.4	0
R3	03	25.34*	-0.15	11
R4	04	12.67*	2.0	1
R5	05	37.10*	3.5	0 **
R6	06	37.10*	0.5	8
R7	07	37.10*	3.5	0 **
R8	08	37.10*	0.5	8
R9d	11	194.57*	6.8	0
R9.3	09	84.16*	3.65	0
R9.4	10	63.35*	1.1	27

* : The volumes given in Tab. 1 of /1/ are divided by 1.105.
**: This value is different from value in Tab. 1 of /1/

Table 1b: Volumes, node centers and sump floor area (case 42)

Cell /1/	CONT	Volume(m^3)	Node center(m)	Sump floor area(m^2)
R1	01	16	2.3	0
R2	02	26	4.4	0
R3	03	28	-0.15	11
R4	04	14	2.0	1
R5	05	41	3.5	0 **
R6	06	41	0.5	8
R7	07	41	3.5	0 **
R8	08	41	0.5	8
R9d	11	215	6.8	0
R9.3	09	93	3.65	0
R9.4	10	70	1.1	27

**: This value is different from value in Tab. 1 of /1/
because in both cells there is no sump defined

Tab.2a Openings connecting the compartments (cases 40,42 and 44)

Opng.	Connecting nodes	Elevation-path(m)	Area(m^2)	Average length(A/l)	cfc[1]
Estg	1 with 8	1.67 -> 1.67	0.04	2.0	0.10 [2]
Rk1	1 with 6	1.70 -> 1.70	0.06	0.08	0.25
RRo	11 with 9	5.20 -> 4.90	29.10	90.0	0.225[2]
RRu	9 with 10	2.20 -> 2.20	32.00	200.0	0.005
U29	11 with 2	5.15 -> 5.15	16.33	200.0	0.28
U36	3 with 6	0.20 -> 0.20	1.13	1.3	0.64
U38	3 with 8	0.20 -> 0.20	1.30	1.5	0.605
U49B	4 with 11	5.10 -> 5.10	2.31	200.0	0.365
U56	5 with 6	2.275-> 1.925	1.68	5.0	0.63
U57	5 with 7	3.30 -> 3.30	1.40	5.6	0.375
U59B	5 with 11	4.825-> 5.175	1.82	5.5	0.675
U78	7 with 8	2.275-> 1.925	1.68	5.0	0.63
U79B	7 with 11	4.825-> 5.175	2.25	6.6	0.655

[1]: Flow loss coeff. is half of the avg. flow coeff. from Tab. 2a in /1/.
[2]: There is no value given in Tab. 2a in /1/.

Tab.2b Openings connecting the compartments (cases 45 and 46)

Opng.	Connecting nodes	Elevation-path(m)	Area(m^2)	Average length(A/l)	cfc[1]
Estg	1 with 8	1.67 -> 1.67	0.04	2.0	1.35
Rk1	1 with 6	1.70 -> 1.70	0.06	0.08	1.35
RRo	11 with 9	5.20 -> 4.90	29.10	90.0	0.5
RRu	9 with 10	2.20 -> 2.20	32.00	200.0	0.5
U29	11 with 2	5.15 -> 5.15	16.33	200.0	0.5
U36	3 with 6	0.20 -> 0.20	1.13	1.3	1.35
U38	3 with 8	0.20 -> 0.20	1.30	1.5	1.35
U49B	4 with 11	5.10 -> 5.10	2.31	200.0	0.5
U56	5 with 6	2.275-> 1.925	1.68	5.0	1.35
U57	5 with 7	3.30 -> 3.30	1.40	5.6	1.35
U59B	5 with 11	4.825-> 5.175	1.82	5.5	1.35
U78	7 with 8	2.275-> 1.925	1.68	5.0	1.35
U79B	7 with 11	4.825-> 5.175	2.25	6.6	1.35

[1]: Flow loss coeff. is half of the avg. flow coeff. from Tab. 2b in /1/.

Table 3a: Structure input for internal structures

Structural Element	Mat.	Surface Side1 Orientation	Side2	Area m^2	Thickness m
Internal Structures					
17	C	8v	10v	28.4	0.30
18	C	6v	10v	28.4	0.30
19	C	4v	10v	4.8	0.30
20	C	7v	9v	36.8	0.30
21	C	5v	9v	36.8	0.30
22	C	4v	9v	6.2	0.30
23	C	3v	8v	17.8	0.56
24	C	3v	6v	17.8	0.56
25	C	3v	4v	3.2	0.53
26	C	1v	8v	7.2	0.80
27	C	1v	6v	7.2	0.80
28	C	1v	4v	2.2	0.80
29	C	1v	7v	5.9	0.80
30	C	1v	5v	5.9	0.80
31	C	2v	7v	13.9	0.37
32	C	2v	5v	13.9	0.37
33	C	2v	4v	2.3	0.37
34	C	7f	8r	14.9	0.35
35	C	5f	6r	12.9	0.35
36	C	11f	7r	17.3	0.35
37	C	11f	5r	17.5	0.35
38	SS	2f	1r	3.1	0.01
39	C	5v	7v	4.0	0.25
40	C	6v	8v	4.1	0.25
41	C	4v	5v	4.4	0.25
42	C	4v	7v	4.4	0.25
43	C	4v	6v	4.4	0.25
44	C	4v	8v	4.4	0.25
45	C	2f	1r	14.3	0.92
46 part of outer shell					
47 part of outer shell					
48	C	1f	3r	7.0	0.30
49	SS	1f	3r	2.0	0.01
50	SS	1f	3r	1.3	0.01
51 (door)	SS	10v	build.	0.4	0.01 *

v: vertical wall r: roof f: floor s: sump

*: not modelled in calculations

Table 3b: Structure input (no second surface defined *)

Structural Element	Mat.	Surface Side1 Orientation	Side2	Area m^2	Thickness m
Outer Shell					
1	C*	10v*	10*	80.5	1.884 **
2	C*	9v*	9*	37.7	1.884 **
3	C*	9v*	9*	66.6	0.466 **
4	C*	11v*	11*	16.5	1.984 **
5	C*	11v*	11*	29.1	0.566 **
6	C*	11r*	11*	86.3	1.436 **
7	C*	11r*	11*	7.8	1.410 **
8	C*	11r*	11*	19.0	1.030 **
46	C*	11r*	11*	8.7	1.216 **
9	C	10s	10*	32.3	3.55
10	C	8f	8*	18.8	3.55
11	C	6f	6*	18.8	3.55
12	C	4f	4*	2.0	3.55
13	C	8s	8*	7.7	2.55
14	C	6s	6*	7.7	2.55
15	C	4s	4*	1.2	2.55
16	C	3s	3*	11.1	2.25
47	SS	11r	11*	4.2	0.01

v: vertical wall r: roof f: floor s: sump

*: means that the values differ from /1/.
**: Thickness of simulant concrete for cases 40 and 42

All structures have a uniform temperature (TUNIF) at t=4068s of 295K (22°C). For structure 47 it is 283K.

Table 3c: Material and thickness of the structural elements 1 to 8 and 46

Structural element	Materials	Thickness m	Thickness of the simulant concrete which was used only for case 40 and 42 **	
1 and 2	coating concrete air gap YTONG	0.002 0.45 0.02 0.24	0.016 0.45 0.384 1.05	sum = 1.884m
3	coating concrete	0.002 0.45	0.016 0.45	sum = 0.466m
4	coating concrete air gap YTONG	0.002 0.55 0.02 0.24	0.016 0.55 0.384 1.05	sum = 1.984m
5	coating concrete	0.002 0.55	0.016 0.55	sum = 0.566m
6	coating concrete	0.002 1.42	0.016 1.42	sum = 1.436m
7	steel liner concrete light conc.	0.002 0.52 0.52	0.00 0.52 0.89	sum = 1.410m
8	steel liner light conc.	0.002 0.60	0.00 1.03	sum = 1.030m
46	coating concrete	0.002 1.20	0.016 1.20	sum = 1.216m

** means that the values differ from /1/.

In case 40 and 42 the thickness of structures 1 to 8 and 46 of the outer shell is calculated from the values given in Table 3c and 4 by multiplying the material thickness of material X in Table 3c with the ratio of heat conductivity of reinforced concrete divided by heat conductivity of material X. For example material YTONG has heat conductivity 0.55W/mK and concrete 2.4W/mK. Ratio = 4.36 which means that the thickness of YTONG in the outer shell structures is multiplied by 4.36.

Table 4: Material properties (according to /1/)

Material	Density kg/m³	Heat Capacity J/kgK	Heat Cond. W/mK	Ratio [1]
Heavy concrete	2400	880	2.4	2.4/2.4 = 1.0
Light concrete	2000	880	1.4	2.4/1.4 = 1.71
YTONG bricks	1000	880	0.55	2.4/0.55 = 4.36
Coating	1500	1200	0.3	2.4/0.3 = 8.0
Steel	7850	480	45.0	2.4/45.0 = 0.05
Air gap	1.25	1000	0.125	2.4/0.3 = 19.2

[1]: Ratio = heat conductivity of heavy concrete divided by heat conductivity of material X.

Table 5: Initial and boundary temperatures (according to /1/)

Cell	Initial Atmospheric Temperatures
1 to 8	298 K = 25°C
11	298 K = 25°C
9 and 10	295 K = 22°C

Boundary	Fixed Temperature
Environment	283 K = 10°C
Soil	283 K = 10°C
Building	295 K = 22°C

All structures of the outer shell have at t=4068s the uniform temperature of 295 K.

Table 6: Steam injection rates to cells 3 and 5

Time sec	h	Mass flow rate -> 5 kg/s	Mass flow rate -> 3 kg/s	Enthalpy J/kg
4068	1.13	0.000		2.680e6
4320	1.20	0.400		2.680e6
5400	1.50	0.375		2.703e6
5436	1.51	0.310		2.703e6
7200	2.00	0.305		2.696e6
7920	2.20	0.420		2.714e6
8712	2.42	0.280		2.714e6
10296	2.86	0.362		2.716e6
12420	3.45	0.367		2.720e6
13104	3.64	0.423		2.730e6
16092	4.47	0.423		2.730e6
16848	4.68	0.369		2.728e6
19440	5.40	0.380		2.728e6
20988	5.83	0.358		2.728e6
23796	6.61	0.358		2.728e6
30996	8.61	0.279		2.728e6
31140	8.65	0.262		2.728e6
38160	10.60	0.205		2.728e6
52020	14.45	0.145		2.722e6
52200	14.50	0.000		2.722e6
57780	16.05	0.000		2.686e6
57960	16.10	0.033		2.686e6
61560	17.10	0.033		2.686e6
61920	17.20	0.124		2.686e6
65520	18.20	0.120		2.709e6
65628	18.23	0.000		2.709e6
81720	22.70	0.000		2.693e6
81797	22.72	0.122		2.693e6
83088	23.08	0.122		2.700e6
83160	23.10	0.000		2.700e6
84024	23.34		0.000	2.734e6
84096	23.36		0.185	2.734e6
87480	24.30		0.180	2.746e6
88380	24.55		0.165	2.746e6
90864	25.24	0.000	0.165	2.746e6
91008	25.28	0.130	0.000	2.699e6
92520	25.70	0.135		2.712e6
108108	30.03	0.135		2.715e6
108180	30.05	0.000		2.715e6

All values agree with those of Table 6 in /1/. They are linearly interpolated.

Table 7a: Air removal and injection rates (case 40)

Time[1] sec	h	Mass flow rate -> 10 kg/s	Mass flow rate -> 3 kg/s	Mass flow rate -> 5 kg/s	Temp. K
the following values are linearly interpolated:					
6280	1.74	0.0000			287**
6300	1.75	-0.0226*			287**
14580	4.05	-0.0226*			287**
15000	4.17	0.0000			287**
51732	14.37	0.0000	0.0000		287**
51840	14.39	0.05067*	0.05067*		287**
52250	14.51	0.05429*	0.05429*		287**
52300	14.53	0.0000	0.0000		287**
52350	14.54	0.0000			287
52380	14.55	0.0543*			287
53100	14.75	0.0724*			287
54972	15.27	0.0724*	0.0000		287
55008	15.28	0.0000	0.07238*		287
55584	15.44		0.07238*		287
55620	15.45		0.0000		287
59148	16.43		0.0000		287
59220	16.45		0.04976*		287
59472	16.52	0.0000	0.04976*		287
59508	16.53	0.0498*	0.0000		287
59760	16.60	0.0498*			287
59800	16.61	0.0000			287
61920	17.20			0.000	383
62028	17.23			0.0977*	523
62748	17.43			0.0977*	567
63756	17.71			0.0977*	564
63864	17.74			0.0977*	517
64296	17.86			0.0977*	517
64332	17.87			0.0977*	548
65592	18.22			0.0977*	529
65628	18.23			0.000	383
the next values are step function input:					
82046	22.79			0.0977*	531
83424	23.17			0.000	383

[1] Injection times differ sometimes slightly from Tab. 7 in /1/.
* All mass flow rates are smaller by a factor of 1.105 as Tab. 7 in /1/.
**Should be at 295K according to Table 7 in /1/.

Table 7b: Air removal and injection rates (case 42,44,45 and 46)

Time[1] sec	h	Mass flow rate -> 10 kg/s	Mass flow rate -> 3 kg/s	Mass flow rate -> 5 kg/s	Temp. K
the following values are linearly interpolated:					
6280	1.74	0.000			287**
6300	1.75	-0.025 *			287**
14580	4.05	-0.025 *			287**
15000	4.17	0.000			287**
51732	14.37	0.000	0.000		287**
51840	14.39	0.056 *	0.056 *		287**
52250	14.51	0.060 *	0.060 *		287**
52300	14.53	0.000	0.000		287**
52350	14.54	0.000			287
52380	14.55	0.060 *			287
53100	14.75	0.080 *			287
54972	15.27	0.080 *	0.000		287
55008	15.28	0.000	0.080 *		287
55584	15.44		0.080 *		287
55620	15.45		0.000		287
59148	16.43		0.000		287
59220	16.45		0.055 *		287
59472	16.52	0.000	0.055 *		287
59508	16.53	0.055 *	0.000		287
59760	16.60	0.055 *			287
59800	16.61	0.000			287
61920	17.20			0.000	383
62028	17.23			0.108 *	523
62748	17.43			0.108 *	567
63756	17.71			0.108 *	564
63864	17.74			0.108 *	517
64296	17.86			0.108 *	517
64332	17.87			0.108 *	548
65592	18.22			0.108 *	529
65628	18.23			0.000	383
the next values are step function input:					
82046	22.79			0.108 *	531
83424	23.17			0.000	383

[1] Injection times differ sometimes slightly from Tab. 7 in /1/.
* All mass flow rates are splitted in tables for N2 (79%) and O2 (21%).
**Should be at 295K according to Table 7 in /1/.

Table 8a: Proposed leakage rate of the containment /1/

Time sec	h	Leakage Rate kg/s
4068	1.13	0.000
4320	1.20	-0.01484
9864	2.74	-0.01484
10116	2.81	-0.01098
23029	6.397	-0.01098
23209	6.447	-0.00672
32508	9.03	-0.00672
32760	9.10	-0.001797
53100	14.75	-0.001797
53111	14.753	-0.01226
108000	30.00	-0.01226

Total leakage 1004 kg

Table 8b: Oxygen leakage rate of the containment (case 40)

Time[1] sec	h	Leakage rate 3-> 12 kg/s	Leakage rate 4-> 12 kg/s	Leakage rate 10-> 12 kg/s	Leakage rate 11-> 12 kg/s
4320	1.20	-0.0025175	-0.0012587	-0.0062936	-0.003357
9864	2.74	-0.002484	-0.0012418	-0.0062089	-0.00
23029	6.397	-0.00152	-0.00076	-0.00380	-0.00
32508	9.03	-0.00040646	-0.00020323	-0.00101615	-0.00
53100	14.75	-0.0020798	-0.0010399	-0.0051995	-0.002773
108000	30.00	-0.00	-0.00	-0.00	-0.00

the above values are step function input

[1] Injection times differ sometimes slightly from Tab. 8 in /1/.
* All mass flow rates are smaller by a factor of 1.105 as Tab. 8 in /1/.

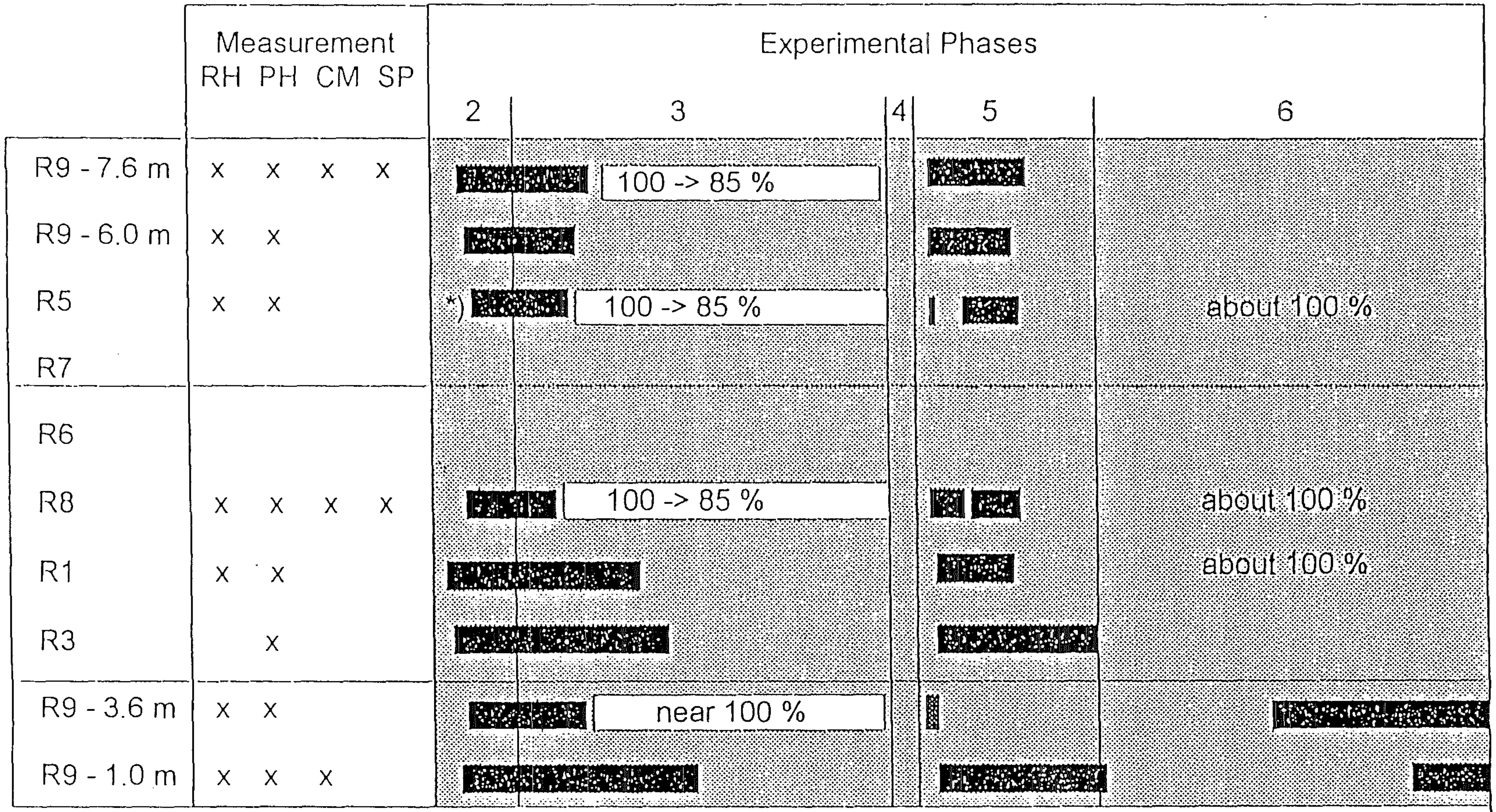
Table 8c: Air leakage rate of the containment (case 42,44,45 and 46)

Time[1] sec	h	Leakage rate 3-> 12 kg/s	Leakage rate 4-> 12 kg/s	Leakage rate 10-> 12 kg/s	Leakage rate 11-> 12 kg/s
4320	1.20	-0.0027825	-0.00139125	-0.00695625	-0.003710
9864	2.74	-0.0027450	-0.00137250	-0.0068625	-0.00
23029	6.397	-0.0016800	-0.00084000	-0.0042000	-0.00
32508	9.03	-0.00044925	-0.000224625	-0.00112313	-0.00
53100	14.75	-0.00229875	-0.001149375	-0.00574688	-0.003064
108000	30.00	-0.00	-0.00	-0.00	-0.00

the above values are step function input

[1] Injection times differ sometimes slightly from Tab. 8 in /1/.
* All mass flow rates are splitted in tables for N2 (79%) and O2 (21%).

Table 9 : Detected fog and measured humidities in VANAM M3



*) stratified, upper part superheated in ph. 2

Legend:
RH humidity sensor
PH extinction photometer
CM calorimeter
SP spectral photometer

fog detected (rh = 100%)

85 % — superheated conditions (rh < 100%) measured

Table 10: Aerosol injection data

Parameter	First aerosol injection	Second aerosol injection
Experimental phase	2	4
Location, room no.	5	5
Period of injection, [h]	17,70 until 18,18	22,92 until 23,08
Duration, [s]	1728	576
Total generated NaOH aerosol mass, [kg]	2.21	0.719
Constant aerosol mass injection rate, [kg/s]	$1.28 \cdot 10^{-3}$	$1.25 \cdot 10^{-3}$
	equal for both injections	
Mass median particle diameter, [µm]	0.2	
(Number median particle diameter, [µm])	(0.058)	
Particle size distribution	log-normal	
Geometric standard deviation	1.9	
Dry theoretical NaOH density, [kg/m³]	2130	
Molecular weight of NaOH, [kg/kmol]	40	
Solubility (Van't Hoff) factor, recommended	2.0	
Dynamic shape factor, recommended	1.0	
Agglomeration shape factor, recommended	1.0	

Table 11: Watermass at the end of calculation

Room	Watermass (at 30h) in kg total condensate plus aerosols case 40	case 42	case 44
R1	27.00 + 0.15	26.95 + 0.15	26.95 + 0.15
R2	8.56	8.52	8.55
R3	27.51	27.09	27.23 + 0.23
R3 sump	1832	1743	1777
R4	10.87	12.48	12.71
R4 sump	580	596	600
R5	45.28	45.32	45.29
R6	38.87 + 0.34	38.94 + 0.34	38.90
R6 sump	2984	2823	2842
R7	46.15 + 0.09	46.18 + 0.05	46.15 + 0.07
R8	46.07 + 0.27	45.41 + 0.27	46.28
R8 sump	3579	3408	3434
R9.3	50.80	50.71	50.61
R9.4	56.02	55.94	55.89
R9.4 sump	8152	8531	8434
dome	97.50 + 0.47	97.48 + 0.25	97.37 + 0.35
sum	17583	17557	17544

To be compared with the total injected steam mass of: 17500 kg

Table 12: Differences of CONTAIN calculations

Case	cfc		Air	O2	Outer Structure		Aerosol	Rad.
	Idel'chick Tab. 2a	/1/ Tab. 2b			Modified	Correct	NaOH	on
40	x			x	x			
42	x		x		x			
44	x		x			x		
45		x	x			x	x	
46		x	x			x	x	x

Tab. 13 CONTAIN input for case 42

```
&&  Run on workstation inrrisc3:
&&
&&  15.1.96: I found that for structure 47 (rupture disk
&&  in dome made of steel) i used the TUNIF of the
&&  building = 295K). This is may be wrong and i should
&&  have used the initial uniform temperature of the
&&  environment, which is 10grd = 283K. So i repeat
&&  case42x as case42xmod today.
&&
&& I assume that structure thicknesses of int. structures which are
&& connected to other cells (Tab. 3b) have to be halfed.
&&
&& Condensation drain flow paths are slightly modified from Fig. 6.
&& They are modelled by engineering overflows and by condensation
&& in lower cells of appropriate cells.
&&
&& Drain flow from dome (cell 11) could not be diverted in to
&& different cells. I model it by overflow to cell 9 after short
&& discussion with Mr. Schwarz (GRS).
&&
&& ---------------------------------------------------------------
&&
&&  cell 1:  central cell                      R1
&&  cell 2:  above cell 1                      R2
&&  cell 3:  below cell 1                      R3
&&  cell 4:  inner ringsegment below dome            R4=R4.1+R4.2
&&  cell 5:  below dome                          R5
&&  cell 6:  below cell 5                      R6
&&  cell 7:  inner ringsegment below dome            R7
&&  cell 8:  below cell 7                      R8
&&  cell 9:  upper annular ring below dome           R9.3
&&  cell 10: lower annular ring below dome           R9.4
&&  cell 11: dome                              R9=R9.1+R9.2
&&  cell 12: environment
&&
&& ---------------------------------------------------------------
    control
       ncells    =  12
       ntitl     =  2
       ntzone    =  11
       nac       =  1  &&  no. of aerosol components < 9
       nsectn    =  10 &&         "      particle sections
     eoi

&& -------------------- materials -------------------------------
   material
compound   n2   o2   h2ol  h2ov
         ss   conc   h2o
   naoh   && aerosol material

thermal
```

flows

```
&& cross-section        flow-loss coeff.   average length
&& area of flowpath        s.o.            (A/l)
&&   Tab. 2a              half of tab-value

   area(1,8)= 0.04      cfc(1,8)=0.1       avl(1,8)= 2.0
   area(1,6)= 0.06      cfc(1,6)=0.25      avl(1,6)= 0.08
   area(9,11)= 29.1     cfc(9,11)=0.225    avl(9,11)= 90.0
   area(9,10)= 32.0     cfc(9,10)=0.005    avl(9,10)= 200.0
   area(2,11)= 16.33    cfc(2,11)=0.28     avl(2,11)= 200.0
   area(3,6)= 1.13      cfc(3,6)=0.64      avl(3,6)= 1.3
   area(3,8)= 1.30      cfc(3,8)=0.605     avl(3,8)= 1.5
   area(4,11)= 2.31     cfc(4,11)=0.365    avl(4,11)= 200.0
   area(5,6)= 1.68      cfc(5,6)=0.63      avl(5,6)= 5.0
   area(5,7)= 1.40      cfc(5,7)=0.375     avl(5,7)= 5.6
   area(5,11)= 1.82     cfc(5,11)=0.675    avl(5,11)= 5.5
   area(7,8)= 1.68      cfc(7,8)=0.63      avl(7,8)= 5.0
   area(7,11)= 2.25     cfc(7,11)=0.655    avl(7,11)= 6.6

&& flow(i,j)= flow:  a constant or initial flow rate; def =0.0
&& cfrflag(i,j)  = 1 means constant rate with kg/s
&& cfrflag(i,j)  =-1 means constant rate with m3/s
&& no cfrflag means: flow is interpreted as initial flow rate

 implicit  =  11   && no. of cells to be solved implicitly

&& -------- elevations of cells (positions of cell-centers)
&& -------- taken from Tab.1

  elevcl(1)= 2.3     elevcl(2)= 4.4    elevcl(3)= -0.15
  elevcl(4)= 2.0     elevcl(5)= 3.5    elevcl(6)= 0.5
  elevcl(7)= 3.5     elevcl(8)= 0.5    elevcl(9)= 3.65
  elevcl(10)= 1.1    elevcl(11)= 6.8   elevcl(12)= 0.0

&& ---------------- elevations of flowpath ends
&& -------- taken from Tab. 2a

  elevfp(1,8)  = 1.67       elevfp(8,1)  = 1.67
  elevfp(1,6)  = 1.70       elevfp(6,1)  = 1.70
  elevfp(11,9)  = 5.20      elevfp(9,11)  = 4.90
  elevfp(9,10)  = 2.2       elevfp(10,9)  = 2.2
  elevfp(11,2)  = 5.15      elevfp(2,11)  = 5.15
  elevfp(3,6)  = 0.20       elevfp(6,3)  = 0.20
  elevfp(3,8)  = 0.20       elevfp(8,3)  = 0.20
  elevfp(11,4)  = 5.1       elevfp(4,11)  = 5.1
  elevfp(5,6)  = 2.275      elevfp(6,5)  = 1.925
  elevfp(5,7)  = 3.30       elevfp(7,5)  = 3.30
  elevfp(11,5)  = 5.175     elevfp(5,11)  = 4.825
  elevfp(7,8)  = 2.275      elevfp(7,5)  = 1.925
  elevfp(11,7)  = 5.175     elevfp(7,11)  = 4.825
```

```
&& engvent  && specifies the engineering vents

   aerosol  h2ol  1.0e-8  0.405  && s.S. 6.13 CONTAIN-desc.

&& ----------------------- times---------------------------
  times  99999. 4068.0   && max. cpu-limit ; start time (s)
   && timinc  edtdto   tstop

       1.0    50.0    14068.     &&
       1.0    50.0    24068.
       1.0    50.0    34068.
       1.0    50.0    44068.
       1.0    50.0    54068.
       1.0    50.0    64068.
       1.0    50.0    74068.
       1.0    50.0    84068.
       1.0    50.0    94068.
       1.0    50.0   100000.
       1.0    50.0   108000.

 shortedt  500  && no. of system timesteps between short edits
 longedt  1000  &&  "  "  edit    "       "    long  "

&& --------------------print output options --------------
   prengsys  praer   prflow  prheat  prlow-cl && praer2

title       && written over every long edit output
      isp37 - benchmark, only therm. hydr.

&&
&& -----------------------    cell input -----------------
&&

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 1
 control
  nhtm     =  10   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
  nspatm   =   10   && max. no of entries in atmosphere source tables
  naensy   =   1   && no of separate eng. systems
  numtbc   =   4    && no of cell level tables
  maxtbc   =   8    && max. no of any cell level table
 eoi

 title
 --- central cell ---    && only one line is allowed

 geometry    16.  2.6  && free initial atmosphere volume; height
    atmos  =  2          && no of materials
      tgas  =  298.
      pgas  =  1.0130e5
      molefrac  n2  =  0.79   o2  =  0.21
```

```
 eoi
 && source = nso && no. of source tables to follow, s.S. 3-120ff
   && eoi

&&   --------------- heat structures --------------
&& assume that average thickness means total thickness of structure
&& i take in aech cell half the thickness and good connection to the
&& neighbouring structure in other cell

 struc
&&  structure (1,1)
&&  lower, middle inner cylinder
&&  no. 26 of Tab. 3b
   name= struc261  type= wall   shape= slab
   tunif= 298.0   slarea= 7.2  nslab= 6     chrlen= 5.
   compound= conc  conc conc conc conc  conc
   x =      0.0 0.01 0.04 0.10 0.2  0.3 0.4
   && no. of cell connected to
    bcouter   icell = 8
    && structure no. in this cell
    strnum = 4 , 1.e20    eoi
   eoi
&&  structure (1,2)
&&  lower, middle inner cylinder
&&  no. 27 of Tab. 3b
   name= struc271  type= wall   shape= slab
   tunif= 298.0   slarea= 7.2  nslab= 6     chrlen= 5.
   compound= conc  conc conc conc conc  conc
   x =      0.0 0.01 0.04 0.10 0.2  0.3 0.4
   && no. of cell connected to
    bcouter   icell = 6
    && structure no. in this cell
    strnum = 4 , 1.e20    eoi
   eoi
&&  structure (1,3)
&&  middle of middle inner cylinder
&&  no. 28 of Tab. 3b
   name= struc281  type= wall   shape= slab
   tunif= 298.0   slarea= 2.2  nslab= 6     chrlen= 5.
   compound= conc  conc conc conc conc  conc
   x =      0.0 0.01 0.04 0.10 0.2  0.3 0.4
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum = 7 , 1.e20    eoi
   eoi
&&  structure (1,4)
&&  upper, middle inner cylinder
&&  no. 29 of Tab. 3b
   name= struc291  type= wall   shape= slab
   tunif= 298.0   slarea= 5.9  nslab= 6     chrlen= 5.
   compound= conc  conc conc conc conc  conc
   x =      0.0 0.01 0.04 0.10 0.2  0.3 0.4
```

```
&& no. of cell connected to
 bcouter   icell = 7
 && structure no. in this cell
 strnum = 5 , 1.e20    eoi
eoi
&& structure (1,5)
&& upper, middle inner cylinder
&& no. 30 of Tab. 3b
name= struc301 type= wall   shape= slab
tunif= 298.0   slarea= 5.9  nslab= 6      chrlen= 5.
compound= conc  conc  conc  conc  conc  conc
x =     0.0  0.01  0.04  0.10  0.2  0.3  0.4
&& no. of cell connected to
 bcouter   icell = 5
 && structure no. in this cell
 strnum = 4 , 1.e20    eoi
eoi
&& structure (1,6)
&& upper, middle inner cylinder; mezzanine central floor
&& no. 48 of Tab. 3b
name= struc481 type= floor  shape= slab
tunif= 298.0   slarea= 7.0  nslab= 5      chrlen= 5.
compound= conc  conc  conc  conc  conc
x =     0.0  0.01  0.04  0.07  0.11  0.15
&& no. of cell connected to
 bcouter   icell = 3
 && structure no. in this cell
 strnum = 4 , 1.e20    eoi
eoi
&& structure (1,7)
&& upper, middle inner cylinder; mezzanine central floor
&& no. 49 of Tab. 3b
name= struc491  type= floor  shape= slab
tunif= 298.0   slarea= 2.0  nslab= 3      chrlen= 5.
compound=  ss   ss   ss
x =     0.0  0.001 0.003  0.005
&& no. of cell connected to
 bcouter   icell = 3
 && structure no. in this cell
 strnum = 5 , 1.e20    eoi
eoi
&& structure (1,8)
&& upper, middle inner cylinder; mezzanine central floor
&& no. 50 of Tab. 3b
name= struc501  type= floor  shape= slab
tunif= 298.0   slarea= 1.3  nslab= 3      chrlen= 5.
compound=  ss   ss   ss
x =     0.0  0.001 0.003  0.005
&& no. of cell connected to
 bcouter   icell = 3
 && structure no. in this cell
 strnum = 6 , 1.e20    eoi
eoi
```

```
&& structure (1,9)
&& upper inner cylinder;central floor R1/R2
&& no. 38 of Tab. 3b
   name= struc381   type= roof   shape= slab
   tunif= 298.0   slarea= 3.1   nslab= 3      chrlen= 5.
   compound=   ss    ss    ss
   x =       0.0  0.001 0.003  0.005
   && no. of cell connected to
    bcouter   icell = 2
    && structure no. in this cell
    strnum  = 4 , 1.e20     eoi
   eoi
&& structure (1,10)
&& upper, middle inner cylinder; outer ring of central floor
&& no. 45 of Tab. 3b
   name= struc451  type= roof   shape= slab
   tunif= 298.0   slarea= 14.3  nslab= 6      chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =       0.0  0.01  0.04  0.10  0.2   0.3  0.46
   && no. of cell connected to
    bcouter   icell = 2
    && structure no. in this cell
    strnum  = 5 , 1.e20     eoi
   eoi

  condense

     aerosol  1   h2ol  0.001

  ht-tran   on   && atmosphere to structures
            off  && lower cell to substructure
            off  && interlayer in lower cell
            off  && lower cell to upper cell
            off  && pool-to-structure radiative transfer

&& no lower cell

     overflow  3

&& &&&&&&&&&&&&&&&&&&&&&&&&

cell 2
 control
  nhtm     =   5   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
  nspatm   =  10   && max. no of entries in atmosphere source tables
  naensy   =   1   && no of separate eng. systems
  numtbc   =  4    && no of cell level tables
  maxtbc   =  8    && max. no of any cell level table
 eoi

 title
 --- room above cell 1 ---
```

```
geometry   26.  1.4  && free initial atmosphere volume; height
  atmos = 2          && no of materials
   tgas = 298.
   pgas = 1.0130e5
   molefrac n2 = 0.79   o2 = 0.21
  eoi
 && source = nso && no. of source tables to follow, s.S. 3-120ff
   && eoi

&&   --------------- heat structures --------------

 struc
&&  structure (2,1)
&&  upper inner cylinder
&&  no. 31 of Tab. 3b
   name= struc312  type= wall    shape= slab
   tunif= 298.0    slarea=13.9  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell = 7
    && structure no. in this cell
    strnum = 6 , 1.e20     eoi
   eoi
&&  structure (2,2)
&&  upper inner cylinder
&&  no. 32 of Tab. 3b
   name= struc322  type= wall    shape= slab
   tunif= 298.0    slarea=13.9  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell = 5
    && structure no. in this cell
    strnum = 5 , 1.e20     eoi
   eoi
&&  structure (2,3)
&&  upper inner cylinder
&&  no. 33 of Tab. 3b
   name= struc332  type= wall    shape= slab
   tunif= 298.0    slarea= 2.3   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell = 4
    && structure no. in this cell
    strnum = 9 , 1.e20     eoi
   eoi
&&  structure (2,4)
&&  upper inner cylinder; central floor R1/R2
&&  no. 38 of Tab. 3b
   name= struc382  type= floor   shape= slab
```

```
   tunif= 298.0   slarea= 3.1  nslab= 3      chrlen= 5.
   compound= ss      ss      ss
   x =      0.0  0.001  0.003  0.005
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 5 , 1.e20     eoi
   eoi
&& structure (2,5)
&& upper, middle inner cylinder;outer ring of central floor
&& no. 45 of Tab. 3b
   name= struc452  type= floor  shape= slab
   tunif= 298.0   slarea=14.3  nslab= 6      chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =      0.0  0.01  0.04  0.10  0.2   0.3  0.46
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 10, 1.e20     eoi
   eoi

  condense

     aerosol   1   h2ol  0.001

  ht-tran   on   && atmosphere to structures
            off  && lower cell to substructure
            off  && interlayer in lower cell
            off  && lower cell to upper cell
            off  && pool-to-structure radiative transfer

&& no lower cell

     overflow  8
&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 3      && with sump and with steam injection
 control
  nhtm    =   7   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
   nsopl    =   4   && "  "  external sources to lower cell layers
   nsppl    =  10   && max. no of entries in lower cell source tables
   nsoatm    =   5   && no of external sources to upper cell atmosphere
   nspatm    =  10   && max. no of entries in atmosphere source tables
   jint     =   5   && no of intermediate layers in lower cell
   jpool    =   1   && 1 if pool layer is used
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- room below cell 1 ---
```

```
geometry    28.  2.3  && free initial atmosphere volume; height
  atmos = 2           && no of materials
    tgas = 298.
    pgas = 1.0130e5
    molefrac  n2 = 0.79 o2 = 0.21
  eoi

 && source = nso && no. of source tables to follow, s.S. 3-120ff
 source = 5

    && source 1: steam injection to cell 3
    && vapour and  enthalpy rates according to Tab. 6
    h2ov = 6
    iflag = 2 &&   linear interpolation is used between points
 && iflag = 1 &&   stepfunction for mass rate

   t = 84024.  84096.  87480.  88380.  90864.  91008.        && s
 mass = 0.      0.185   0.180   0.165   0.165   0.0          && kg/s
 enth = 2.734e6 2.734e6 2.746e6 2.746e6 2.746e6 2.699e6        && J/kg
      eoi

    && source 2: air injection rates to cell 3
              && and temperatures
    o2 = 12
    iflag = 2 &&   linear interpolation is used between points
 && iflag = 1 &&   stepfunction for mass rate

   t = 51732.  51840.  52250.  52300.  54972.  55008. 55584.  && s
      55620.  59148.  59220.  59472.  59508.

 mass = 0.     0.01176  0.0126   0.0     0.0    0.0168 0.0168  && kg/s
      0.      0.0     0.01155  0.01155 0.0

 temp = 287.    287.    287.    287.    287.    287.   287.    && k
      287.    287.    287.    287.    287.
      eoi

    && source 3: air injection rates to cell 3
              && and temperatures
    n2 = 12
    iflag = 2 &&   linear interpolation is used between points
 && iflag = 1 &&   stepfunction for mass rate

   t = 51732.  51840.  52250.  52300.  54972.  55008. 55584.  && s
      55620.  59148.  59220.  59472.  59508.

 mass = 0.     0.04424  0.0474   0.0     0.0    0.0632 0.0632  && kg/s
      0.      0.0     0.04345  0.04345 0.0

 temp = 287.    287.    287.    287.    287.    287.   287.    && k
      287.    287.    287.    287.    287.
      eoi
```

```
    && source 4: air removal(leakage) from cell 3

    o2 = 6
  && iflag = 2 &&   linear interpolation is used between points
    iflag = 1 &&   stepfunction for mass rate

   t =    4320.   9864. 23029. 32508.    53100.  108000.    && s

mass = -0.584325e-3 -5.7645e-4 -3.528e-4 -9.43425e-5 -4.827375e-4 0.0

       eoi

    && source 5: air removal(leakage) from cell 3

    n2 = 6
  && iflag = 2 &&   linear interpolation is used between points
    iflag = 1 &&   stepfunction for mass rate

   t =    4320.   9864. 23029. 32508.    53100.  108000.    && s

mass = -2.198175e-3 -2.16855e-3 -1.3272e-3 -3.549075e-4 -1.8160125e-3
                                              0.0
       eoi
&&    --------------- heat structures --------------

 struc
&&  structure (3,1)
&&  lower inner cylinder
&&  no. 23 of Tab. 3b
   name= struc233 type= wall    shape= slab
   tunif= 298.0    slarea=17.8   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.28
   && no. of cell connected to
    bcouter    icell = 8
    && structure no. in this cell
    strnum  = 3 , 1.e20     eoi
   eoi
&&  structure (3,2)
&&  lower inner cylinder
&&  no. 24 of Tab. 3b
   name= struc243 type= wall    shape= slab
   tunif= 298.0    slarea=17.8   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.28
   && no. of cell connected to
    bcouter    icell = 6
    && structure no. in this cell
    strnum  = 3 , 1.e20     eoi
   eoi
&&  structure (3,3)
&&  lower inner cylinder
&&  no. 25 of Tab. 3b
```

```
   name= struc253 type= wall   shape= slab
   tunif= 298.0   slarea= 3.2  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.08 0.15 0.265
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&& structure (3,4)
&& lower, middle inner cylinder; mezzanine central floor
&& no. 48 of Tab. 3b
   name= struc483 type= roof   shape= slab
   tunif= 298.0   slarea= 7.0  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&& structure (3,5)
&& lower, middle inner cylinder; mezzanine central roof
&& no. 49 of Tab. 3b
   name= struc493  type= roof   shape= slab
   tunif= 298.0   slarea= 2.0  nslab= 3     chrlen= 5.
   compound=  ss   ss   ss
   x =      0.0 0.001 0.003 0.005
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 7 , 1.e20    eoi
   eoi
&& structure (3,6)
&& lower, middle inner cylinder; mezzanine central roof
&& no. 50 of Tab. 3b
   name= struc503  type= roof   shape= slab
   tunif= 298.0   slarea= 1.3  nslab= 3     chrlen= 5.
   compound=  ss   ss   ss
   x =      0.0 0.001 0.003 0.005
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 8 , 1.e20    eoi
   eoi
&& structure (3,7)
&& basemat, center (sump region)
&& no. 16 of Tab. 3b
   name= str16-03 type= floor  shape= slab
   tunif= 295.0   slarea= 11.1  nslab= 12     chrlen= 5.
   compound= conc  conc conc conc conc conc conc
          conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
```

```
          0.8  1.1   1.5   1.9   2.25
   eoi

  condense

     aerosol  1   h2ol  0.001

  ht-tran   on   && atmosphere to structures
         off  && lower cell to substructure
         on   && interlayer in lower cell
         on   && lower cell to upper cell
         on   && pool-to-structure radiative transfer

low-cell
  geometry   11. && floor area, about 350cm thick concrete
             && i modelled 3.1m
    bc  283.   && basemat boundary condition temperature

  interm   lay-name = conc5    temp = 283.
    compos=1 conc =   42240.              && ca. 1.6m dick
  eoi
  interm   lay-name = conc4    temp = 283.
    compos=1 conc =    21120.             && ca. 0.8m dick
  eoi
  interm   lay-name = conc3    temp = 283.
    compos=1 conc =    10560.             && ca. 0.4m dick
  eoi
  interm  lay-name = conc2     temp = 283.
    compos=1 conc =     5280.            && ca. 0.2m dick
  eoi
  interm   lay-name = conc1    temp = 283.
  &&
    compos=1 conc =     2640. && mass in kg; ca. 0.1m dick
  eoi
  pool          temp   = 283.
    compos=1     h2ol   = 0.1  && one material: compos = 1
                         && water, mass(kg) initially
    physics
      boil            && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool

    eoi    &&   end of physics
  eoi      &&   end of pool
 eoi       &&   end of lower cell
 && -------------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

 cell 4   && with sump
 control
  nhtm     =  11   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
  nsopl    =   4   && "  "  external sources to lower cell layers
```

```
 nsppl   =  10   && max. no of entries in lower cell source tables
 nsoatm  =   2   && no. of external sources to upper cell atmosphere
 nspatm  =  10   && max. no of entries in atmosphere source tables
 jint    =   5   && no of intermediate layers in lower cell
 jpool   =   1   && 1 if pool layer is used
 numtbc  =   4   && no of cell level tables
 maxtbc  =   8   && max. no of any cell level table
eoi

title
--- inner ring segment below dome R4 = R4.1 + R4.2

geometry   14.  6.1 && free initial atmosphere volume; heightdiff.
   atmos = 2          && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac  n2 = 0.79  o2 = 0.21
   eoi

   source = 2

     && source 1: air removal(leakage) from cell 4
     o2 = 6
  && iflag = 2 &&   linear interpolation is used between points
     iflag = 1 &&   stepfunction for mass rate

    t = 4320.   9864.   23029. 32508.   53100. 108000.  && s

mass = -2.921625e-4 -2.88225e-4 -1.764e-4 -4.717125e-5 -2.4136875e-4
              0.0
        eoi

     && source 2: air removal(leakage) from cell 4
     n2 = 6
  && iflag = 2 &&   linear interpolation is used between points
     iflag = 1 &&   stepfunction for mass rate

    t = 4320.   9864.   23029. 32508.   53100. 108000.  && s

mass = -1.0990875e-3 -1.084275e-3 -6.636e-4 -1.7745375e-4 -9.0800625e-4
            0.0
        eoi

&&    --------------- heat structures --------------

 struc
&&  structure (4,1)
&&  upper middle cylinder
&&  no. 22 of Tab. 3b
   name= struc224 type= wall    shape= slab
   tunif= 298.0    slarea= 6.2   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.07  0.11  0.15
```

```
   && no. of cell connected to
    bcouter   icell = 9
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&& structure (4,2)
&& vertical partition R4/R5
&& no. 41 of Tab. 3b
   name= struc414 type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5    chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 5
    && structure no. in this cell
    strnum = 7 , 1.e20    eoi
   eoi
&& structure (4,3)
&& vertical partition R4/R7
&& no. 42 of Tab. 3b
   name= struc424 type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5    chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 7
    && structure no. in this cell
    strnum = 7 , 1.e20    eoi
   eoi
&& structure (4,4)
&& vertical partition R4/R6
&& no. 43 of Tab. 3b
   name= struc434 type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5    chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 6
    && structure no. in this cell
    strnum = 6 , 1.e20    eoi
   eoi
&& structure (4,5)
&& vertical partition R4/R8
&& no. 44 of Tab. 3b
   name= struc444 type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5    chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 8
    && structure no. in this cell
    strnum = 6 , 1.e20    eoi
   eoi
```

```
&& structure (4,6)
&& lower inner cylinder
&& no. 25 of Tab. 3b
   name= struc254 type= wall   shape= slab
   tunif= 298.0   slarea= 3.2   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.265
   && no. of cell connected to
    bcouter   icell = 3
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&& structure (4,7)
&& middle of middle inner cylinder
&& no. 28 of Tab. 3b
   name= struc284 type= wall   shape= slab
   tunif= 298.0   slarea= 2.2   nslab= 6      chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =      0.0  0.01  0.04  0.10  0.2   0.3  0.4
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&& structure (4,8)
&& lower middle cylinder
&& no. 19 of Tab. 3b
   name= strc194 type= wall   shape= slab
   tunif= 295.0   slarea= 4.8   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter   icell = 10
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&& structure (4,9)
&& upper inner cylinder
&& no. 33 of Tab. 3b
   name= struc334 type= wall   shape= slab
   tunif= 298.0   slarea= 2.3   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter   icell = 2
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&& structure (4,10)
&& basemat, second ring
&& no. 12 of Tab. 3b
   name= str12-04 type= floor   shape= slab
   tunif= 295.0   slarea=  2.0  nslab= 13     chrlen= 5.
```

```
   compound = conc  conc  conc  conc  conc  conc  conc
           conc  conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.10  0.20  0.35  0.5  0.7
          0.8  1.1   1.5   2.0   2.7   3.55
   eoi
&& structure (4,11)
&& basemat, third ring (sump region)
&& no. 15 of Tab. 3b
   name = str15-04 type = floor  shape = slab
   tunif = 295.0   slarea =  1.2  nslab = 12     chrlen = 5.
   compound = conc  conc  conc  conc  conc  conc  conc
           conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.10  0.20  0.35  0.5  0.7
          0.8  1.1   1.5   2.0   2.55
   eoi

  condense

    aerosol  1  h2ol  0.001

  ht-tran  on  && atmosphere to structures
          off  && lower cell to substructure
          on   && interlayer in lower cell
          on   && lower cell to upper cell
          on   && pool-to-structure radiative transfer

low-cell
  geometry   1. && floor area, about 250cm thick concrete
               && i modelled 3.1m
    bc  283.   && basemat boundary condition temperature

  interm  lay-name = conc5   temp = 283.
    compos = 1 conc =    3840.          && ca. 1.6m dick
  eoi
  interm  lay-name = conc4   temp = 283.
    compos = 1 conc =     1920.         && ca. 0.8m dick
  eoi
  interm  lay-name = conc3   temp = 283.
    compos = 1 conc =      960.         && ca. 0.4m dick
  eoi
  interm  lay-name = conc2   temp = 283.
    compos = 1 conc =      480.         && ca. 0.2m dick
  eoi
  interm  lay-name = conc1   temp = 283.
    compos = 1 conc =      240. && mass in kg; ca. 0.1m dick
  eoi
  pool          temp  = 283.
    compos = 1     h2ol  = 0.1  && one material: compos = 1
                        && water, mass(kg) initially
    physics
      boil           && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool
```

```
      eoi    &&  end of physics
    eoi      &&  end of pool
  eoi        &&  end of lower cell
  && -------------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 5    && no sump
          && cell with steam injection
 control
  nhtm     =   7  && no of heat transfer structures
  mxslab   =  20  && "  "  nodes in any  "
  nspatm   =  10  && max. no of entries in atmosphere source tables
  nsoatm   =   5  && no of external sources to upper cell atmosphere
  naensy   =   1  && no of separate eng. systems
  numtbc   =   4  && no of cell level tables
  maxtbc   =   8  && max. no of any cell level table
 eoi

 title
 --- cell between cells 6 and 11 && only one line is allowed

 geometry    41. 2.45  && free initial atmosphere volume; height
    atmos = 2          && no of materials
      tgas = 298.
      pgas = 1.0130e5
      molefrac  n2 = 0.79 o2 = 0.21
    eoi
   && source = nso && no. of source tables to follow, s.S. 3-120ff
  source = 5

   && source 1
      h2ov = 35
      iflag = 2 &&   linear interpolation is used between points
   && iflag = 1 &&   stepfunction for mass rate
   && vapour and  enthalpy rates according to tab. 6

    t = 4068.  4320.  5400.  5436.  7200.  7920.  8712.  && s
        10296. 12420. 13104. 16092. 16848. 19440. 20988.
        23796. 30996. 31140. 38160. 52020. 52200. 57780.
        57960. 61560. 61920. 65520. 65628. 81720. 81797.
        83088. 83160. 90864  91008. 92520. 108108. 108180.
  mass = 0.     0.4    0.375  0.310  0.305  0.420  0.280  && kg/s
        0.362  0.367  0.423  0.423  0.369  0.380  0.358
        0.358  0.279  0.262  0.205  0.145  0.0    0.0
        0.033  0.033  0.124  0.120  0.0    0.0    0.122
        0.122  0.0    0.0    0.130  0.135  0.135  0.0
 enth = 2.680e6 2.680e6 2.703e6 2.703e6 2.696e6 2.714e6 2.714e6 && J/kg
        2.716e6 2.720e6 2.730e6 2.730e6 2.728e6 2.728e6 2.728e6
        2.728e6 2.728e6 2.728e6 2.728e6 2.722e6 2.722e6 2.686e6
        2.686e6 2.686e6 2.686e6 2.709e6 2.709e6 2.693e6 2.693e6
        2.700e6 2.700e6 2.746e6 2.699e6 2.712e6 2.715e6 2.715e6
        eoi
```

```
    && source 2
    && air injection rates to cell 5
    o2 =  9
    iflag = 2 &&  linear interpolation is used between points
 && iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t = 61920. 62028. 62748. 63756. 63864. 64296. 64332. && s
      65592. 65628.

 mass = 0.0  0.02268  0.02268 0.02268 0.02268 0.02268 0.02268
      0.02268 0.0

 temp = 383.  523.  567.  564.  517.  517.  548.  && k
      529.  283.
      eoi

    && source 3
    && air injection rates to cell 5
    n2 =  9
    iflag = 2 &&  linear interpolation is used between points
 && iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t = 61920. 62028. 62748. 63756. 63864. 64296. 64332. && s
      65592. 65628.

 mass = 0.0  0.08532  0.08532 0.08532 0.08532 0.08532 0.08532
      0.08532 0.0

 temp = 383.  523.  567.  564.  517.  517.  548.  && k
      529.  283.
      eoi

    && source 4
    && air injection rates to cell 5
    o2 =  3
 && iflag = 2 &&  linear interpolation is used between points
    iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t =  0.0  82046.  83424.

 mass =  0.0  0.02268  0.0

 temp =  383.  531.  383.
      eoi

    && source 5
```

```
   && air injection rates to cell 5
   n2 =  3
 && iflag = 2 &&  linear interpolation is used between points
   iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t =  0.0   82046.  83424.

 mass =  0.0   0.08532  0.0

 temp =  383.   531.   383.
      eoi

 &&   --------------- heat structures --------------

 struc
 && structure (5,1)
 && upper middle cylinder
 && no. 21 of Tab. 3b
   name= struc215  type= wall   shape= slab
   tunif= 298.0   slarea=36.8  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 9
    && structure no. in this cell
    strnum = 2 , 1.e20    eoi
   eoi
 && structure (5,2)
 && upper middle cylinder, mezzanine floor (sump not modelled)
 && no. 35 of Tab. 3b
   name= struc355  type= floor  shape= slab
   tunif= 298.0   slarea=12.9  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.08 0.12 0.175
   && no. of cell connected to
    bcouter   icell = 6
    && structure no. in this cell
    strnum = 5 , 1.e20    eoi
   eoi
 && structure (5,3)
 && upper inner cylinder, vertical partition
 && no. 39 of Tab. 3b
   name= struc395  type= wall   shape= slab
   tunif= 298.0   slarea= 4.0  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 7
    && structure no. in this cell
    strnum = 4 , 1.e20    eoi
   eoi
```

```
&& structure (5,4)
&& upper, middle inner cylinder
&& no. 30 of Tab. 3b
   name= struc305  type= wall    shape= slab
   tunif= 298.0    slarea= 5.9   nslab= 6       chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =        0.0  0.01  0.04  0.10  0.2   0.3  0.4
   && no. of cell connected to
    bcouter    icell  =  1
    && structure no. in this cell
    strnum  =  5 , 1.e20     eoi
   eoi
&& structure (5,5)
&& upper inner cylinder
&& no. 32 of Tab. 3b
   name= struc325 type= wall    shape= slab
   tunif= 298.0    slarea=13.9   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell  =  2
    && structure no. in this cell
    strnum  =  2 , 1.e20     eoi
   eoi
&& structure (5,6)
&& upper roof
&& no. 37 of Tab. 3b
   name= struc375 type= roof    shape= slab
   tunif= 298.0    slarea=17.5   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell  =  11
    && structure no. in this cell
    strnum  =  2 , 1.e20     eoi
   eoi
&& structure (5,7)
&& vertical partition R5/R4
&& no. 41 of Tab. 3b
   name= struc415  type= wall    shape= slab
   tunif= 298.0    slarea= 4.4   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter    icell  =  4
    && structure no. in this cell
    strnum  =  2 , 1.e20     eoi
   eoi

  condense

     aerosol   1    h2ol  0.001
```

```
ht-tran  on   && atmosphere to structures
         off  && lower cell to substructure
         off  && interlayer in lower cell
         off  && lower cell to upper cell
         off  && pool-to-structure radiative transfer

 && no lower cell

    overflow 6
&& &&&&&&&&&&&&&&&&&&&&&&&&&&&

 cell 6   && with sump
 control
  nhtm    =  8  && no of heat transfer structures
  mxslab  = 20  && "  " nodes in any "
  nsopl   =  4  && "  " external sources to lower cell layers
  nsppl   = 10  && max. no of entries in lower cell source tables
  jint    =  5  && no of intermediate layers in lower cell
  jpool   =  1  && 1 if pool layer is used
  numtbc  =  4  && no of cell level tables
  maxtbc  =  8  && max. no of any cell level table
 eoi

 title
 --- below cell 5

 geometry  41. 2.95 && free initial atmosphere volume; heightdiff.
   atmos = 2          && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac   n2 = 0.79 o2 = 0.21
   eoi
  && source = nso && no. of source tables to follow, s.S. 3-120ff
     && eoi

 &&   -------------- heat structures --------------

  struc
 &&  structure (6,1)
 &&  lower middle cylinder
 &&  no. 18 of Tab. 3b
    name= struc186 type= wall   shape= slab
    tunif= 298.0   slarea=28.4   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter   icell = 10
     && structure no. in this cell
     strnum = 2 , 1.e20    eoi
    eoi
 &&  structure (6,2)
 &&  vertical partition R6/R8
 &&  no. 40 of Tab. 3b
```

```
   name= struc406  type= wall    shape= slab
   tunif= 298.0    slarea= 4.1   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =       0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter   icell  = 8
    && structure no. in this cell
    strnum  = 2 , 1.e20     eoi
   eoi
&&  structure (6,3)
&&  lower inner cylinder
&&  no. 24 of Tab. 3b
   name= struc246 type= wall    shape= slab
   tunif= 298.0    slarea =17.8  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =       0.0  0.01  0.04  0.08  0.15  0.28
   && no. of cell connected to
    bcouter   icell  = 3
    && structure no. in this cell
    strnum  = 2 , 1.e20     eoi
   eoi
&&  structure (6,4)
&&  lower, middle inner cylinder
&&  no. 27 of Tab. 3b
   name= struc276  type= wall    shape= slab
   tunif= 298.0    slarea= 7.2   nslab= 6      chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =       0.0  0.01  0.04  0.10  0.2   0.3  0.4
   && no. of cell connected to
    bcouter   icell  = 1
    && structure no. in this cell
    strnum  = 2 , 1.e20     eoi
   eoi
&&  structure (6,5)
&&  upper middle cylinder, mezzanine floor (sump not modelled)
&&  no. 35 of Tab. 3b
   name= struc356  type= roof    shape= slab
   tunif= 298.0    slarea =12.9  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =       0.0  0.01  0.04  0.08  0.12  0.175
   && no. of cell connected to
    bcouter   icell  = 5
    && structure no. in this cell
    strnum  = 2 , 1.e20     eoi
   eoi
&&  structure (6,6)
&&  vertical partition R4/R6
&&  no. 43 of Tab. 3b
   name= struc436  type= wall    shape= slab
   tunif= 298.0    slarea= 4.4   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =       0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
```

```
    bcouter   icell = 4
    && structure no. in this cell
    strnum = 4 , 1.e20    eoi
   eoi
&& structure (6,7)
&& basemat, second ring
&& no. 11 of Tab. 3b
   name= str11-06 type= floor  shape= slab
   tunif= 295.0   slarea= 18.8 nslab= 13     chrlen= 5.
   compound= conc  conc conc conc conc conc conc
          conc  conc conc conc conc conc
   x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
          0.8 1.1  1.5  2.0  2.7  3.55
   eoi
&& structure (6,8)
&& basemat, third ring (sump region)
&& no. 14 of Tab. 3b
   name= str14-06 type= floor  shape= slab
   tunif= 295.0   slarea=  7.7 nslab= 12     chrlen= 5.
   compound= conc  conc conc conc conc conc conc
          conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
          0.8 1.1  1.5  2.0  2.55
   eoi

  condense

    aerosol  1  h2ol 0.001

  ht-tran  on   && atmosphere to structures
          off  && lower cell to substructure
          on   && interlayer in lower cell
          on   && lower cell to upper cell
          on   && pool-to-structure radiative transfer

low-cell
  geometry   8. && floor area, between 250cm and 3.5m thick
             && i modelled 3.1m
    bc  283.   && basemat boundary condition temperature

  interm   lay-name = conc5   temp = 283.
    compos=1 conc =     30720.          && ca. 1.6m dick
  eoi
  interm   lay-name = conc4   temp = 283.
    compos=1 conc =     15360.          && ca. 0.8m dick
  eoi
  interm   lay-name = conc3   temp = 283.
    compos=1 conc =      7680.          && ca. 0.4m dick
  eoi
  interm  lay-name = conc2   temp = 283.
    compos=1 conc =      3840.          && ca. 0.2m dick
  eoi
  interm   lay-name = conc1   temp = 283.
```

```
  &&
    compos=1 conc  =      1920. && mass in kg; ca. 0.1m dick
  eoi
  pool          temp  = 283.
    compos=1     h2ol  = 0.1  && one material: compos = 1
                         && water, mass(kg) initially
    physics
      boil             && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool

    eoi   &&  end of physics
  eoi     &&  end of pool
 eoi      &&  end of lower cell
 && -------------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 7    && no sump
 control
  nhtm     =  7  && no of heat transfer structures
  mxslab   =  20  && "  "  nodes in any  "
  naensy   =  1  && no of separate eng. systems
  numtbc   =   4  && no of cell level tables
  maxtbc   =   8  && max. no of any cell level table
 eoi

 title
 --- cell between cells 8 and 11

 geometry   41. 2.45  && free initial atmosphere volume; height
   atmos = 2          && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac  n2 = 0.79 o2 = 0.21
   && satrat
   && massfrac
   && moles
   && masses
    eoi
   && source = nso && no. of source tables to follow, s.S. 3-120ff
     && eoi

 &&    --------------- heat structures --------------

  struc
 &&  structure (7,1)
 &&  upper middle cylinder
 &&  no. 20 of Tab. 3b
    name= struc207  type= wall   shape= slab
    tunif= 298.0    slarea=36.8  nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0 0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
```

```
    bcouter    icell = 9
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&& structure (7,2)
&& upper middle cylinder, mezzanine floor (sump not modelled)
&& no. 34 of Tab. 3b
   name= struc347  type= floor   shape= slab
   tunif= 298.0   slarea=14.9  nslab= 5      chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.08 0.12 0.175
   && no. of cell connected to
    bcouter    icell = 8
    && structure no. in this cell
    strnum = 5 , 1.e20    eoi
   eoi
&& structure (7,3)
&& upper ceiling
&& no. 36 of Tab. 3b
   name= struc367  type= roof   shape= slab
   tunif= 298.0   slarea=17.3  nslab= 5      chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.08 0.12 0.175
   && no. of cell connected to
    bcouter    icell = 11
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&& structure (7,4)
&& upper inner cylinder, vertical partition R5/R7
&& no. 39 of Tab. 3b
   name= struc397  type= wall   shape= slab
   tunif= 298.0   slarea= 4.0  nslab= 5      chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter    icell = 5
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&& structure (7,5)
&& upper, middle inner cylinder
&& no. 29 of Tab. 3b
   name= struc297  type= wall   shape= slab
   tunif= 298.0   slarea= 5.9  nslab= 6      chrlen= 5.
   compound= conc  conc conc conc conc  conc
   x =      0.0 0.01 0.04 0.10 0.2  0.3 0.4
   && no. of cell connected to
    bcouter    icell = 1
    && structure no. in this cell
    strnum = 4 , 1.e20    eoi
   eoi
&& structure (7,6)
```

```
&&  upper inner cylinder
&&  no. 31 of Tab. 3b
   name= struc317 type= wall   shape= slab
   tunif= 298.0   slarea=13.9   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell = 2
    && structure no. in this cell
    strnum  = 1 , 1.e20     eoi
   eoi
&&  structure (7,7)
&&  vertical partition R4/R7
&&  no. 42 of Tab. 3b
   name= struc427  type= wall   shape= slab
   tunif= 298.0   slarea= 4.4   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter    icell = 4
    && structure no. in this cell
    strnum  = 3 , 1.e20     eoi
   eoi

  condense

     aerosol   1   h2ol  0.001

  ht-tran   on    && atmosphere to structures
            off  && lower cell to substructure
            off  && interlayer in lower cell
            off  && lower cell to upper cell
            off  && pool-to-structure radiative transfer

 && no lower cell

 && assume overflow from cell 7 to 8
 && then the condensed water is collected in sump of R8
 && engineer overfl78   0 0 0 0.
 &&    overflow  7  8   0.01
 && eoi
      overflow  8
&& &&&&&&&&&&&&&&&&&&&&&&&&&&

 cell 8    && with sump
 control
  nhtm     =   8   && no of heat transfer structures
  mxslab   =  20   && "  " nodes in any  "
  nsopl    =   4   && "  "  external sources to lower cell layers
  nsppl    =  10   && max. no of entries in lower cell source tables
  nspatm   =  10   && max. no of entries in atmosphere source tables
  jint     =   5   && no of intermediate layers in lower cell
  jpool    =   1   && 1 if pool layer is used
```

```
 numtbc  =   4   && no of cell level tables
 maxtbc  =   8   && max. no of any cell level table
eoi

title
--- below cell 7

geometry  41. 2.95 && free initial atmosphere volume; heightdiff.
   atmos = 2          && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac  n2 = 0.79 o2 = 0.21
   eoi
  && source = nso && no. of source tables to follow, s.S. 3-120ff
     && eoi

&&    --------------- heat structures --------------

 struc
&&  structure (8,1)
&&  lower middle cylinder
&&  no. 17 of Tab. 3b
    name= struc178 type= wall   shape= slab
    tunif= 298.0   slarea=28.4  nslab= 5     chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter    icell = 10
     && structure no. in this cell
     strnum = 1 , 1.e20     eoi
    eoi
&&  structure (8,2)
&&  vertical partition R6/R8
&&  no. 40 of Tab. 3b
    name= struc408  type= wall   shape= slab
    tunif= 298.0   slarea= 4.1   nslab= 5     chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.06  0.09  0.125
    && no. of cell connected to
     bcouter    icell = 6
     && structure no. in this cell
     strnum = 2 , 1.e20     eoi
    eoi
&&  structure (8,3)
&&  lower inner cylinder
&&  no. 23 of Tab. 3b
    name= struc238 type= wall   shape= slab
    tunif= 298.0   slarea=17.8   nslab= 5     chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.08  0.15  0.28
    && no. of cell connected to
     bcouter    icell = 3
     && structure no. in this cell
```

```
    strnum  =  1 , 1.e20      eoi
   eoi
&&  structure (8,4)
&&  lower, middle inner cylinder
&&  no. 26 of Tab. 3b
   name= struc268  type= wall    shape= slab
   tunif= 298.0    slarea= 7.2   nslab= 6       chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =        0.0  0.01  0.04  0.10  0.2   0.3  0.4
   && no. of cell connected to
    bcouter    icell  =  1
    && structure no. in this cell
    strnum  =  1 , 1.e20      eoi
   eoi
&&  structure (8,5)
&&  lower middle cylinder, mezzanine floor (sump not modelled)
&&  no. 34 of Tab. 3b
   name= struc348  type= roof    shape= slab
   tunif= 298.0    slarea=14.9   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.08  0.12  0.175
   && no. of cell connected to
    bcouter    icell  =  7
    && structure no. in this cell
    strnum  =  2 , 1.e20      eoi
   eoi
&&  structure (8,6)
&&  vertical partition R4/R8
&&  no. 44 of Tab. 3b
   name= struc448  type= wall    shape= slab
   tunif= 298.0    slarea= 4.4   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter    icell  =  4
    && structure no. in this cell
    strnum  =  5 , 1.e20      eoi
   eoi
&&  structure (8,7)
&&  basemat, second ring
&&  no. 10 of Tab. 3b
   name= str10-08 type= floor   shape= slab
   tunif= 295.0    slarea= 18.8  nslab= 13      chrlen= 5.
   compound= conc   conc  conc  conc  conc  conc  conc
            conc  conc  conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.10  0.20  0.35  0.5   0.7
          0.8  1.1   1.5   2.0   2.7   3.55
   eoi
&&  structure (8,8)
&&  basemat, third ring (sump region)
&&  no. 13 of Tab. 3b
   name= str13-08 type= floor   shape= slab
   tunif= 295.0    slarea=  7.7  nslab= 12      chrlen= 5.
```

```
  compound= conc  conc  conc  conc  conc  conc  conc
         conc  conc  conc  conc  conc
  x =      0.0  0.01  0.04  0.10  0.20  0.35  0.5  0.7
         0.8  1.1   1.5   2.0   2.55
  eoi

 condense

  aerosol  1  h2ol  0.001

 ht-tran  on  && atmosphere to structures
          off && lower cell to substructure
          on  && interlayer in lower cell
          on  && lower cell to upper cell
          on  && pool-to-structure radiative transfer

low-cell
 geometry   8. && floor area, between 250cm and 3.5m thick
              && i modelled 3.1m
   bc  283.   && basemat boundary condition temperature

 interm  lay-name = conc5   temp = 283.
   compos=1 conc =    30720.          && ca. 1.6m dick
 eoi
 interm  lay-name = conc4   temp = 283.
   compos=1 conc =    15360.          && ca. 0.8m dick
 eoi
 interm  lay-name = conc3   temp = 283.
   compos=1 conc =     7680.          && ca. 0.4m dick
 eoi
 interm  lay-name = conc2   temp = 283.
   compos=1 conc =     3840.          && ca. 0.2m dick
 eoi
 interm  lay-name = concl   temp = 283.
 &&
   compos=1 conc =     1920. && mass in kg; ca. 0.1m dick
 eoi
 pool         temp  = 283.
   compos=1    h2ol  = 0.1  && one material: compos = 1
                          && water, mass(kg) initially
   physics
     boil          && activates pool boiling model
     && settle  && allows direct aerosol settling onto pool

   eoi   &&  end of physics
  eoi    &&  end of pool
 eoi     &&  end of lower cell
 && -------------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 9  && no sump
        && gets all condensed water of dome and puts it to
```

```
        && sump in cell 10 via overflow.

control
 nhtm    =  5  && no of heat transfer structures
 mxslab  = 20  && "  " nodes in any  "
 nspatm  = 10  && max. no of entries in atmosphere source tables
 naensy  =  1  && no of separate eng. systems
 numtbc  =  4  && no of cell level tables
 maxtbc  =  8  && max. no of any cell level table
eoi

title
--- upper annular ring below dome = R9.3

geometry   93. 2.9  && free initial atmosphere volume; height
   atmos = 2         && no of materials
    tgas = 295.
    pgas = 1.0130e5
    molefrac   n2 = 0.79 o2 = 0.21
   eoi

&&    --------------- heat structures --------------

 struc
&&  structure (9,1)
&&  upper middle cylinder
&&  no. 20 of Tab. 3b
    name= struc209  type= wall   shape= slab
    tunif= 298.0   slarea=36.8   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0 0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter    icell = 7
     && structure no. in this cell
     strnum  =  1 , 1.e20     eoi
    eoi
&&  structure (9,2)
&&  upper middle cylinder
&&  no. 21 of Tab. 3b
    name= struc219  type= wall   shape= slab
    tunif= 298.0   slarea=36.8   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0 0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter    icell = 5
     && structure no. in this cell
     strnum  =  1 , 1.e20     eoi
    eoi
&&  structure (9,3)
&&  upper middle cylinder
&&  no. 22 of Tab. 3b
    name= struc229  type= wall   shape= slab
    tunif= 298.0   slarea= 6.2   nslab= 5      chrlen= 5.
```

```
   compound = conc   conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter    icell  = 4
    && structure no. in this cell
    strnum  = 1 , 1.e20     eoi
   eoi
&&  structure (9,4)
&&  middle outer cylinder
&&  no. 2  of Tab. 3b
&&  i modell it by 188.4 cm of concrete
   name = str02-9  type = wall    shape = slab
   tunif = 295.0    slarea = 37.7  nslab = 12     chrlen = 5.
   compound = conc   conc  conc  conc  conc  conc  conc
            conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.10  0.20  0.35  0.5   0.7
          0.8  1.1   1.3   1.5   1.884
   eoi
&&  structure (9,5)
&&  i modell it by 46.6 cm of concrete (with coating)
&&  middle outer cylinder
&&  no. 3  of Tab. 3b
   name = str03-9  type = wall    shape = slab  iouter  = 12
   tunif = 295.0    slarea = 66.6  nslab = 6      chrlen = 5.
   compound = conc   conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.10  0.20  0.3   0.466
   eoi

  condense

    aerosol   1   h2ol  0.001

  ht-tran   on    && atmosphere to structures
           off  && lower cell to substructure
           off  && interlayer in lower cell
           off  && lower cell to upper cell
           off  && pool-to-structure radiative transfer

 && no lower cell

    overflow  10
&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 10   && with sump
       && cell with air injection/removal
 control
  nhtm     =   5   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
  nsopl    =   4   && "  "  external sources to lower cell layers
  nsppl    =  10   && max. no of entries in lower cell source tables
  nspatm   =  10   && max. no of entries in atmosphere source tables
  nsoatm   =   4   && no of external sources to upper cell atmosphere
  jint     =   5   && no of intermediate layers in lower cell
```

```
 jpool    =   1   && 1 if pool layer is used
 numtbc   =   4   && no of cell level tables
 maxtbc   =   8   && max. no of any cell level table
eoi

title
--- lower annular ring below dome = R9.4

geometry   70. 2.2   && free initial atmosphere volume; height
   atmos = 2          && no of materials
     tgas = 295.
     pgas = 1.0130e5
     molefrac  n2 = 0.79 o2 = 0.21
   eoi

   source = 4

  && source 1: air removal and injection from/to  cell 10
     o2 = 13      && and according temperatures
     iflag = 2 &&   linear interpolation is used between points
  && iflag = 1 &&   stepfunction for mass rate

    t =  6280.   6300.  14580. 15000.                && s
        52350.  52380.  53100. 54972. 55008.           && s
        59472.  59508.  59760. 59800.                 && s

 mass = 0.0    -5.25e-3 -5.25e-3 0.0                  && kg/s
       0.0     0.0126  0.0168  0.0168 0.0            && kg/s
       0.0     0.01155    0.01155  0.0               && kg/s

 temp = 287.    287.    287.    287.                  && k
       287.    287.    287.    287.  287.            && k
       287.    287.    287.    287.                 && k
     eoi

  && source 2: air removal and injection from/to  cell 10
     n2 = 13      && and according temperatures
     iflag = 2 &&   linear interpolation is used between points
  && iflag = 1 &&   stepfunction for mass rate

    t =  6280.   6300.  14580. 15000.                && s
        52350.  52380.  53100. 54972. 55008.           && s
        59472.  59508.  59760. 59800.                 && s

 mass = 0.0    -1.975e-2 -1.975e-2 0.0               && kg/s
       0.0     0.0474   0.0632 0.0632  0.0          && kg/s
       0.0     0.04345    0.04345  0.0              && kg/s

 temp = 287.    287.    287.    287.                  && k
       287.    287.    287.    287.  287.            && k
       287.    287.    287.    287.                 && k
     eoi
```

```
    && source 3: air removal(leakage) from cell 10

    o2 = 6
  && iflag = 2 &&  linear interpolation is used between points
    iflag = 1 &&  stepfunction for mass rate

   t =  4320.  9864.   23029.  32508.   53100. 108000.0  && s

mass = -1.4608125e-3 -1.441125e-3 -8.82e-4 -2.358563e-4 -1.2068438e-3
            0.0
      eoi

    && source 4: air removal(leakage) from cell 10

    n2 = 6
  && iflag = 2 &&  linear interpolation is used between points
    iflag = 1 &&  stepfunction for mass rate

   t =  4320.  9864.   23029.  32508.   53100. 108000.0  && s

mass = -5.4954375e-3 -5.421375e-3 -0.003318 -8.872687e-4 -4.5400312e-3
            0.0
      eoi

&&    --------------- heat structures --------------

 struc
&&  structure (10,1)
&&  lower middle cylinder
&&  no. 17 of Tab. 3b
   name= strc1710 type= wall    shape= slab
   tunif= 295.0   slarea=28.4  nslab= 5      chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter   icell = 8
    && structure no. in this cell
    strnum = 1 , 1.e20     eoi
   eoi
&&  structure (10,2)
&&  lower middle cylinder
&&  no. 18 of Tab. 3b
   name= strc1810 type= wall    shape= slab
   tunif= 295.0   slarea=28.4  nslab= 5      chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter   icell = 6
    && structure no. in this cell
    strnum = 1 , 1.e20     eoi
   eoi
&&  structure (10,3)
&&  lower middle cylinder
```

```
&& no. 19 of Tab. 3b
   name= strc1910 type= wall   shape= slab
   tunif= 295.0   slarea= 4.8  nslab= 5      chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum  = 8 , 1.e20    eoi
   eoi
&& structure (10,4)
&& i modell it by 1.884 m of concrete
&& lower outer cylinder
&& no. 1  of Tab. 3b
   name= str01-10 type= wall   shape= slab
   tunif= 295.0   slarea= 80.5 nslab= 12     chrlen= 5.
   compound= conc  conc conc conc conc conc conc
          conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
         0.9 1.1  1.35 1.6  1.884
   eoi
&& structure (10,5)
&& basemat, outer ring (sumpregion)
&& no. 9  of Tab. 3b
   name= str09-10 type= floor  shape= slab
   tunif= 295.0   slarea= 32.3 nslab= 13     chrlen= 5.
   compound= conc  conc conc conc conc conc conc
          conc  conc conc conc conc conc
   x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
         0.8 1.1  1.5  2.0  2.7  3.55
   eoi

  condense

    aerosol  1  h2ol 0.001

  ht-tran  on  && atmosphere to structures
         off && lower cell to substructure
         on  && interlayer in lower cell
         on  && lower cell to upper cell
         on  && pool-to-structure radiative transfer

low-cell
  geometry  27. && floor area, about 350cm thick concrete
            && i modelled 3.1m
    bc 283.  && basemat boundary condition temperature

  interm  lay-name = conc5  temp = 283.
    compos=1 conc =  103680.          && ca. 1.6m dick
  eoi
  interm  lay-name = conc4  temp = 283.
    compos=1 conc =   51840.          && ca. 0.8m dick
  eoi
```

```
  interm   lay-name = conc3    temp = 283.
    compos=1 conc =     25920.            && ca. 0.4m dick
  eoi
  interm  lay-name = conc2     temp = 283.
    compos=1 conc =     12960.            && ca. 0.2m dick
  eoi
  interm   lay-name = conc1    temp = 283.
    compos=1 conc =      6480. && mass in kg; ca. 0.1m dick
  eoi
  pool          temp  = 283.
    compos=1      h2ol  = 0.1  && one material: compos = 1
                             && water, mass(kg) initially
    physics
      boil            && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool

    eoi    &&   end of physics
  eoi      &&   end of pool
eoi        &&   end of lower cell
&& -------------------------------------------------------


&& &&&&&&&&&&&&&&&&&&&&&&&&

cell 11   && no sump

control
 nhtm     =   9   && no of heat transfer structures
 mxslab   =  20   && "  "  nodes in any  "
 nspatm   =  10   && max. no of entries in atmosphere source tables
 nsoatm   =   2   && no of external sources to upper cell atmosphere
 naensy   =   1   && no of separate eng. systems
 numtbc   =   4   && no of cell level tables
 maxtbc   =   8   && max. no of any cell level table
eoi

title
--- dome = R9.1 + R9.2

geometry  215. 3.4 && free initial atmosphere volume; heightdiff.
   atmos = 2            && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac    n2 = 0.79 o2 = 0.21
   eoi

   source = 2
     && source 1: air removal(leakage) from cell 11
     o2 = 6
  && iflag = 2 &&   linear interpolation is used between points
     iflag = 1 &&   stepfunction for mass rate

    t =    4320.     9864.  23029.   32508.  53100. 108000.  && s
```

```
mass = -7.791e-4   0.0    0.0    0.0   -6.4344e-4 0.0  && kg/s

      eoi

   && source 2: air removal(leakage) from cell 11
   n2 = 6
 && iflag = 2 &&  linear interpolation is used between points
   iflag = 1 &&  stepfunction for mass rate

  t =   4320.   9864.   23029.   32508.  53100. 108000.  && s

 mass =-0.0029309   0.0     0.0     0.0  -0.00242056 0.0   && kg/s

      eoi


&&   --------------- heat structures --------------

 struc
&&  structure (11,1)
&&  upper floor of dome
&&  no. 36 of Tab. 3b
   name= strc3611 type= floor  shape= slab
   tunif= 298.0   slarea=17.3  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.08 0.13 0.185
   && no. of cell connected to
    bcouter   icell = 7
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&&  structure (11,2)
&&  upper floor of dome
&&  no. 37 of Tab. 3b
   name= strc3711 type= floor  shape= slab
   tunif= 298.0   slarea=17.5  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.08 0.13 0.185
   && no. of cell connected to
    bcouter   icell = 5
    && structure no. in this cell
    strnum = 6 , 1.e20    eoi
   eoi
&&  structure (11,3)
&&  i modell it by 198.4 cm of concrete
&&  upper outer cylinder
&&  no. 4  of Tab. 3b
   name= str04-11 type= wall   shape= slab
   tunif= 295.0   slarea= 16.5  nslab= 12     chrlen= 5.
   compound= conc  conc conc conc conc conc conc
            conc  conc conc conc conc
   x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
```

```
        0.9  1.1   1.35  1.6   1.984
   eoi
&&  structure (11,4)
&&  upper outer cylinder
&&  i modell it by 56.6 cm of concrete
&&  no. 5  of Tab. 3b
   name= str05-11 type= wall    shape= slab
   tunif= 295.0    slarea= 29.1  nslab= 6       chrlen= 5.
   compound= conc   conc  conc  conc  conc  conc
   x =       0.0  0.01  0.04  0.10  0.20  0.35  0.566
   eoi
&&  structure (11,5)
&&  upper cone
&&  i modell it by 142 cm of concrete
&&  no. 6  of Tab. 3b
   name= str06-11 type= roof    shape= slab
   tunif= 295.0    slarea= 86.3  nslab= 9       chrlen= 5.
   compound= conc  conc  conc  conc  conc  conc  conc conc conc
   x =   0.0  0.01  0.04  0.10  0.20  0.35  0.55  0.9  1.2  1.436
   eoi
&&  structure (11,6)
&&  lower cone
&&  i modell it by 121.6 cm of concrete
&&  no. 46  of Tab. 3b
   name= str46-11 type= roof    shape= slab
   tunif= 295.0    slarea=  8.7  nslab= 8       chrlen= 5.
   compound= conc   conc  conc  conc  conc  conc  conc conc
   x =       0.0  0.01  0.04  0.10  0.20  0.35  0.55  0.9  1.216
   eoi
&&  structure (11,7)
&&  top flange, top ring
&&  i modell it by  141 cm of concrete
&&  no. 7  of Tab. 3b
   name= str07-11 type= roof    shape= slab
   tunif= 295.0    slarea=  7.8  nslab= 10     chrlen= 5.
   compound= conc conc conc conc conc conc conc conc conc conc
   x =  0.0 0.01 0.04  0.1 0.2 0.35 0.5 0.75 1.0 1.2 1.41
   eoi
&&  structure (11,8)
&&  top cover
&&  i modell it by 103 cm of concrete
&&  no. 8  of Tab. 3b
   name= str08-11 type= roof    shape= slab
   tunif= 295.0    slarea= 19.0  nslab= 8       chrlen= 5.
   compound= conc  conc  conc conc  conc  conc  conc conc
   x =  0.0 0.01 0.04  0.1  0.2  0.35  0.55  0.8 1.03
   eoi
&&  structure (11,9)
&&  top cover
&&  it is now connected to environment by tunif  =  283.0
   name= str47-11 type= roof    shape= slab
&&  tunif= 295.0    slarea=  4.2  nslab= 4       chrlen= 5.
   tunif= 283.0    slarea=  4.2  nslab= 4       chrlen= 5.
```

```
    compound=  ss    ss    ss    ss
    x =       0.0 0.001 0.003 0.006 0.01
    eoi

  condense

     aerosol   1   h2ol  0.001

  ht-tran   on   && atmosphere to structures
            off  && lower cell to substructure
            off  && interlayer in lower cell
            off  && lower cell to upper cell
            off  && pool-to-structure radiative transfer

 && no lower cell

 && assume overflow from cell 11 to 9
 && i dont know how to split condensed water into different cells
 && as it is proposed by Fig. 6. I take 100% flow to R9.3=cell 9.
 && i checked this approach with Mr. Schwarz (12.7.95)

 && engineer overf119   0 0 0 0.
 &&    overflow  11 9   0.01
 && eoi
       overflow  10  && from case 28 on
&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

 && ------------------------ cell 12  environment
  cell 12
 control
 eoi
 title
 ------ environment ------
 geometry  1.e15 1.e15
    atmos = 2  pgas = 1.0130e5  tgas = 283.
              molefrac n2 = 0.79   o2 = 0.21
    eoi
  eoi

eof
```

Tab. 14 INPUT for case 46

```
&&  6.3.96:  Now i add radiation according to siccams
&&  input. But i use 0.94 for emsvt and no cess. This
&&  gives case46x.
&&
&&  5.3.96:  case45x was o.k. till aerosol injection at
&&  64000s. Then it stopped with the old error.
&&  I made a restart with increased timinc=2sec and this
&&  helped. This was case45xr.
&&
&&  4.3.96:  I add additionally NaOH to case44 and take cfc-
&&  values of Tab. 2b which are about 2 times larger and more
&&  symetrical. They were used by the other ISP-CONTAIN users.
&&  Aerosol input like siccama.
&&  This gives case45.
&&
&&  1.3.96 :  After the ISP37 workshop I learned that my
&&  simplification of the outer shell structure (its simulation
&&  by only concrete) was too coarse and caused the 'good'
&&  low pressure. But the temperaures of these structures
&&  have a very high impact on the condensation rates and
&&  tsat, saturation rate etc. These are the dominat effects
&&  for the aerosol behaviour.
&&  Now I use userdef data for coating, gap, ytong and light
&&  concrete. This is case44.
&&
&& I assume that structure thicknesses of int. structures which are
&& connected to other cells (Tab. 3b) have to be halfed.
&&
&& Drain flow from dome (cell 11) could not be diverted in to
&& different cells. I model it by overflow to cell 9 after short
&& discussion with Mr. Schwarz (GRS).
&&
&& ---------------------------------------------------------------
&&
&&  cell 1:  central cell                       R1
&&  cell 2:  above cell 1                       R2
&&  cell 3:  below cell 1                       R3
&&  cell 4:  inner ringsegment below dome            R4=R4.1+R4.2
&&  cell 5:  below dome                          R5
&&  cell 6:  below cell 5                        R6
&&  cell 7:  inner ringsegment below dome            R7
&&  cell 8:  below cell 7                        R8
&&  cell 9:  upper annular ring below dome           R9.3
&&  cell 10: lower annular ring below dome           R9.4
&&  cell 11: dome                               R9=R9.1+R9.2
&&  cell 12: environment
&&
&& ---------------------------------------------------------------
    control
        ncells    =  12
        ntitl     =  2
```

```
      ntzone     =  11
      nac        =  2  &&  no. of aerosol components < 9
      nsectn     =  15 &&          "      particle sections
    eoi

&& --------------------- materials -------------------------------
material
   compound  n2   o2   h2ol  h2ov
          ss   conc   h2o
    aernames  naoh                  && aerosol material
    userdef   coat gap ytong licon
     userdat  && according to Klepac
      coat   solid
      molew   70.
      rho  2  273.1  1500.  573.1  1500.
      cond 2  273.1   0.30   573.1  0.30 && th. cond. W/mK
      sph  2  273.1  1200.  573.1  1200. && spec. heat J/kgK
      enth 2  273.1  1.e5   573.1  4.6e5  && J/kg from Klepac
      eoi

      gap    solid
      molew   28.
      rho  2  273.1  1.25   573.1  1.25
      cond 2  273.1   0.125  573.1  0.125
      sph  2  273.1  1000.  573.1  1000.
      enth 2  273.1  1.e5   573.1  4.05e5  &&  from Klepac
      eoi

      ytong  solid
      molew   50.
      rho  2  273.1  1000.  573.1  1000.
      cond 2  273.1  0.55   573.1  0.55
      sph  2  273.1   880.  573.1   880.
      enth 2  273.1  1.e5   573.1  3.64e5  &&  from Klepac
      eoi

      licon  solid
      molew   50.
      rho  2  273.1  2000.  573.1  2000.
      cond 2  273.1  1.40   573.1  1.40
      sph  2  273.1   880.  573.1   880.
      enth 2  273.1  1.e5   573.1  3.64e5  &&  from Klepac
      eoi
     eoi

  aerosol   && s.S. 3-31 ff.
     diam1  =  1.e-7    diam2  =  1.e-4      densty  =  1100.
     tgas1 = 273.  tgas2 = 500.
     pgas1 = 8.e4  pgas2 = 5.e5     && siccama
    solaer
      solubl  =  2.0     && Tab.10
    &&  surten  =  73.0e-3   commented according to siccama (4.3.96)
      molewt  =  40.0
```

```
      eoi
&&  mat. , mass median diam., geom. standard dev.

    naoh   2.e-7   0.642
    h2ol   1.e-7   0.693

thermal

flows
&&
&&
&&    contain def of cfc   :    delta p = cfc rho v**2
&&
&&    standard def of zeta :    delta p = zeta rho/2 v**2
&&    (e.g. in siemens data) and for grs ??
&&
&&    follows                  cfc = zeta/2
&&
&&
&& cross-section        flow-loss coeff.   average length
&& area of flowpath         s.o.           (A/l)
                 && cfc(1,8) ??
   area(1,8)= 0.04      cfc(1,8)=1.35      avl(1,8)= 2.0
   area(1,6)= 0.06      cfc(1,6)=1.35      avl(1,6)= 0.08
   area(9,11)= 29.1     cfc(9,11)=0.5      avl(9,11)= 90.0
   area(9,10)= 32.0     cfc(9,10)=0.5      avl(9,10)= 200.0
   area(2,11)= 16.33    cfc(2,11)=0.5      avl(2,11)= 200.0
   area(3,6)= 1.13      cfc(3,6)=1.35      avl(3,6)= 1.3
   area(3,8)= 1.30      cfc(3,8)=1.35      avl(3,8)= 1.5
   area(4,11)= 2.31     cfc(4,11)=0.5      avl(4,11)= 200.0
   area(5,6)= 1.68      cfc(5,6)=1.35      avl(5,6)= 5.0
   area(5,7)= 1.40      cfc(5,7)=1.35      avl(5,7)= 5.6
   area(5,11)= 1.82     cfc(5,11)=1.35     avl(5,11)= 5.5
   area(7,8)= 1.68      cfc(7,8)=1.35      avl(7,8)= 5.0
   area(7,11)= 2.25     cfc(7,11)=1.35     avl(7,11)= 6.6

&& flow(i,j)= flow:  a constant or initial flow rate; def =0.0
&& cfrflag(i,j) = 1 means constant rate with kg/s
&& cfrflag(i,j) =-1 means constant rate with m3/s
&& no cfrflag means: flow is interpreted as initial flow rate

 implicit = 11   && no. of cells to be solved implicitly

&& -------- elevations of cells (positions of cell-centers)

  elevcl(1)= 2.3     elevcl(2)= 4.4    elevcl(3)= -0.15
  elevcl(4)= 2.0     elevcl(5)= 3.5    elevcl(6)= 0.5
  elevcl(7)= 3.5     elevcl(8)= 0.5    elevcl(9)= 3.65
  elevcl(10)= 1.1    elevcl(11)= 6.8   elevcl(12)= 0.0

&& ---------------- elevations of flowpath ends
  elevfp(1,8) = 1.67      elevfp(8,1) = 1.67
  elevfp(1,6) = 1.70      elevfp(6,1) = 1.70
```

```
   elevfp(11,9) = 5.20      elevfp(9,11) = 4.90
   elevfp(9,10) = 2.2       elevfp(10,9) = 2.2
   elevfp(11,2) = 5.15      elevfp(2,11) = 5.15
   elevfp(3,6) = 0.20       elevfp(6,3) = 0.20
   elevfp(3,8) = 0.20       elevfp(8,3) = 0.20
   elevfp(11,4) = 5.1       elevfp(4,11) = 5.1
   elevfp(5,6) = 2.275      elevfp(6,5) = 1.925
   elevfp(5,7) = 3.30       elevfp(7,5) = 3.30
   elevfp(11,5) = 5.175     elevfp(5,11) = 4.825
   elevfp(7,8) = 2.275      elevfp(7,5) = 1.925
   elevfp(11,7) = 5.175     elevfp(7,11) = 4.825

 && engvent   && specifies the engineering vents

 && ----------------------- times----------------------------
  times  99999. 4068.0   && max. cpu-limit ; start time (s)

   && timinc  edtdto   tstop
       1.0    50.0    14068.
       1.0    50.0    24068.
       1.0    50.0    34068.
       1.0    50.0    44068.
       2.0    50.0    54068.
       2.0    50.0    64068.
       1.0    50.0    74068.
       1.0    50.0    84068.
       1.0    50.0    94068.
       1.0    50.0   100000.
       1.0    50.0   108000.

 shortedt  500  && no. of system timesteps between short edits
 longedt  1000  && " " edit     "       "   long  "

 && --------------------print output options --------------
   prengsys  praer   prflow  prheat  prlow-cl && praer2
     && prfiss

title        && written over every long edit output
     isp37 - benchmark, only therm. hydr.


 &&
 && -----------------------    cell input ------------------
 &&

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 1
 control
  nhtm     =  10   && no of heat transfer structures
  mxslab   =  20   && " " nodes in any "
  nspatm   =  10   && max. no of entries in atmosphere source tables
  naensy   =   1   && no of separate eng. systems
  numtbc   =   4   && no of cell level tables
```

```
 maxtbc  =  8    && max. no of any cell level table
eoi

title
--- central cell ---    && only one line is allowed

geometry    16.  2.6  && free initial atmosphere volume; height
   atmos  =  2          && no of materials
     tgas  =  298.
     pgas  =  1.0130e5
     molefrac  n2  =  0.79  o2  =  0.21
   eoi

&&    --------------- heat structures --------------
&& assume that average thickness means total thickness of structure
&& i take in aech cell half the thickness and good connection to the
&& neighbouring structure in other cell

 struc
&&  structure (1,1)
&&  lower, middle inner cylinder
&&  no. 26 of Tab. 3b
    name= struc261  type= wall    shape= slab
    tunif= 298.0    slarea= 7.2   nslab= 6      chrlen= 5.
    compound= conc   conc  conc  conc  conc   conc
    x =       0.0  0.01  0.04  0.10  0.2   0.3  0.4
    && no. of cell connected to
     bcouter    icell  =  8
     && structure no. in this cell
     strnum  =  4 , 1.e20     eoi
    eoi
&&  structure (1,2)
&&  lower, middle inner cylinder
&&  no. 27 of Tab. 3b
    name= struc271  type= wall    shape= slab
    tunif= 298.0    slarea= 7.2   nslab= 6      chrlen= 5.
    compound= conc   conc  conc  conc  conc   conc
    x =       0.0  0.01  0.04  0.10  0.2   0.3  0.4
    && no. of cell connected to
     bcouter    icell  =  6
     && structure no. in this cell
     strnum  =  4 , 1.e20     eoi
    eoi
&&  structure (1,3)
&&  middle of middle inner cylinder
&&  no. 28 of Tab. 3b
    name= struc281  type= wall    shape= slab
    tunif= 298.0    slarea= 2.2   nslab= 6      chrlen= 5.
    compound= conc   conc  conc  conc  conc   conc
    x =       0.0  0.01  0.04  0.10  0.2   0.3  0.4
    && no. of cell connected to
     bcouter    icell  =  4
     && structure no. in this cell
```

```
   strnum  =  7 , 1.e20     eoi
  eoi
&&  structure (1,4)
&&  upper, middle inner cylinder
&&  no. 29 of Tab. 3b
  name= struc291  type= wall    shape= slab
  tunif= 298.0    slarea= 5.9   nslab= 6      chrlen= 5.
  compound= conc   conc  conc  conc  conc   conc
  x =       0.0  0.01  0.04  0.10  0.2   0.3  0.4
  && no. of cell connected to
   bcouter    icell  =  7
   && structure no. in this cell
   strnum  =  5 , 1.e20     eoi
  eoi
&&  structure (1,5)
&&  upper, middle inner cylinder
&&  no. 30 of Tab. 3b
  name= struc301  type= wall    shape= slab
  tunif= 298.0    slarea= 5.9   nslab= 6      chrlen= 5.
  compound= conc   conc  conc  conc  conc   conc
  x =       0.0  0.01  0.04  0.10  0.2   0.3  0.4
  && no. of cell connected to
   bcouter    icell  =  5
   && structure no. in this cell
   strnum  =  4 , 1.e20     eoi
  eoi
&&  structure (1,6)
&&  upper, middle inner cylinder; mezzanine central floor
&&  no. 48 of Tab. 3b
  name= struc481 type= floor   shape= slab
  tunif= 298.0    slarea= 7.0   nslab= 5      chrlen= 5.
  compound= conc   conc  conc  conc  conc
  x =       0.0  0.01  0.04  0.07  0.11  0.15
  && no. of cell connected to
   bcouter    icell  =  3
   && structure no. in this cell
   strnum  =  4 , 1.e20     eoi
  eoi
&&  structure (1,7)
&&  upper, middle inner cylinder; mezzanine central floor
&&  no. 49 of Tab. 3b
  name= struc491  type= floor   shape= slab
  tunif= 298.0    slarea= 2.0   nslab= 3      chrlen= 5.
  compound=   ss     ss     ss
  x =       0.0  0.001 0.003  0.005
  && no. of cell connected to
   bcouter    icell  =  3
   && structure no. in this cell
   strnum  =  5 , 1.e20     eoi
  eoi
&&  structure (1,8)
&&  upper, middle inner cylinder; mezzanine central floor
&&  no. 50 of Tab. 3b
```

```
   name= struc501  type= floor   shape= slab
   tunif= 298.0    slarea= 1.3   nslab= 3      chrlen= 5.
   compound=   ss    ss    ss
   x =       0.0  0.001 0.003  0.005
   && no. of cell connected to
    bcouter    icell  = 3
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&&  structure (1,9)
&&  upper inner cylinder;central floor R1/R2
&&  no. 38 of Tab. 3b
   name= struc381   type= roof   shape= slab
   tunif= 298.0    slarea= 3.1   nslab= 3      chrlen= 5.
   compound=   ss    ss    ss
   x =       0.0  0.001 0.003  0.005
   && no. of cell connected to
    bcouter    icell  = 2
    && structure no. in this cell
    strnum  = 4 , 1.e20    eoi
   eoi
&&  structure (1,10)
&&  upper, middle inner cylinder; outer ring of central floor
&&  no. 45 of Tab. 3b
   name= struc451  type= roof   shape= slab
   tunif= 298.0    slarea= 14.3  nslab= 6      chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =       0.0  0.01  0.04  0.10  0.2   0.3  0.46
   && no. of cell connected to
    bcouter    icell  = 2
    && structure no. in this cell
    strnum  = 5 , 1.e20    eoi
   eoi

 condense

    aerosol   1   h2ol  0.001

 ht-tran   on   && atmosphere to structures
           off  && lower cell to substructure
           off  && interlayer in lower cell
           off  && lower cell to upper cell
           off  && pool-to-structure radiative transfer

&& no lower cell

    overflow  3

rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94
  && same no. as nhtm plus 1 if pool is specified
  kmx 1.0
  gaswal 2.5
```

```
  eoi

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 2
 control
  nhtm     =   5   && no of heat transfer structures
  mxslab   =  20   && "  " nodes in any  "
  nspatm   =  10   && max. no of entries in atmosphere source tables
  naensy   =   1   && no of separate eng. systems
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- room above cell 1 ---

 geometry   26.  1.4  && free initial atmosphere volume; height
   atmos = 2          && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac n2 = 0.79   o2 = 0.21
   eoi

 &&    --------------- heat structures --------------

  struc
 &&  structure (2,1)
 &&  upper inner cylinder
 &&  no. 31 of Tab. 3b
    name= struc312  type= wall   shape= slab
    tunif= 298.0   slarea=13.9  nslab= 5      chrlen= 5.
    compound= conc  conc  conc  conc  conc
    x =     0.0  0.01  0.04  0.08  0.13  0.185
    && no. of cell connected to
     bcouter   icell = 7
     && structure no. in this cell
     strnum = 6 , 1.e20     eoi
    eoi
 &&  structure (2,2)
 &&  upper inner cylinder
 &&  no. 32 of Tab. 3b
    name= struc322  type= wall   shape= slab
    tunif= 298.0   slarea=13.9  nslab= 5      chrlen= 5.
    compound= conc  conc  conc  conc  conc
    x =     0.0  0.01  0.04  0.08  0.13  0.185
    && no. of cell connected to
     bcouter   icell = 5
     && structure no. in this cell
     strnum = 5 , 1.e20     eoi
    eoi
 &&  structure (2,3)
 &&  upper inner cylinder
```

```
&&  no. 33 of Tab. 3b
   name= struc332  type= wall   shape= slab
   tunif= 298.0   slarea= 2.3  nslab= 5     chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =     0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum  = 9 , 1.e20    eoi
   eoi
&&  structure (2,4)
&&  upper inner cylinder; central floor R1/R2
&&  no. 38 of Tab. 3b
   name= struc382  type= floor  shape= slab
   tunif= 298.0   slarea= 3.1  nslab= 3     chrlen= 5.
   compound= ss    ss    ss
   x =     0.0  0.001  0.003  0.005
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 5 , 1.e20    eoi
   eoi
&&  structure (2,5)
&&  upper, middle inner cylinder;outer ring of central floor
&&  no. 45 of Tab. 3b
   name= struc452  type= floor  shape= slab
   tunif= 298.0   slarea=14.3  nslab= 6     chrlen= 5.
   compound= conc  conc  conc  conc  conc  conc
   x =     0.0  0.01  0.04  0.10  0.2  0.3  0.46
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 10, 1.e20    eoi
   eoi

 condense

   aerosol  1  h2ol  0.001

 ht-tran  on  && atmosphere to structures
          off  && lower cell to substructure
          off  && interlayer in lower cell
          off  && lower cell to upper cell
          off  && pool-to-structure radiative transfer

&& no lower cell

   overflow  8

rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94
  && same no. as nhtm plus 1 if pool is specified
  kmx 1.0
```

```
  gaswal 2.5
  eoi

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 3      && with sump and with steam injection
 control
  nhtm     =   7   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
  nsopl    =   4   && "  "  external sources to lower cell layers
  nsppl    =  10   && max. no of entries in lower cell source tables
  nsoatm   =   5   && no of external sources to upper cell atmosphere
  nspatm   =  10   && max. no of entries in atmosphere source tables
  nsoaer   =   1   && no of external aerosol sources
  nspaer   =  10   && max. no of entries in aerosol source tables
  jint     =   5   && no of intermediate layers in lower cell
  jpool    =   1   && 1 if pool layer is used
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- room below cell 1 ---

 geometry   28.  2.3  && free initial atmosphere volume; height
    atmos = 2          && no of materials
      tgas = 298.
      pgas = 1.0130e5
      molefrac   n2 = 0.79 o2 = 0.21
    eoi

  && source = nso && no. of source tables to follow, s.S. 3-120ff
 source = 5

    && source 1: steam injection to cell 3
    && vapour and  enthalpy rates according to Tab. 6
    h2ov = 6
    iflag = 2 &&   linear interpolation is used between points
  && iflag = 1 &&   stepfunction for mass rate

   t = 84024.  84096.  87480.  88380.  90864.  91008.        && s
 mass = 0.      0.185   0.180   0.165   0.165   0.0           && kg/s
 enth = 2.734e6 2.734e6 2.746e6 2.746e6 2.746e6 2.699e6        && J/kg
      eoi

    && source 2: air injection rates to cell 3
             && and temperatures
    o2 = 12
    iflag = 2 &&   linear interpolation is used between points
  && iflag = 1 &&   stepfunction for mass rate

   t = 51732.  51840.  52250.  52300.  54972.  55008. 55584.  && s
      55620.  59148.  59220.  59472.  59508.
```

```
mass = 0.     0.01176  0.0126   0.0     0.0   0.0168 0.0168  && kg/s
       0.     0.0     0.01155  0.01155 0.0

temp = 287.   287.   287.   287.   287.   287.   287.    && k
       287.   287.   287.   287.   287.
       eoi

    && source 3: air injection rates to cell 3
            && and temperatures
    n2 = 12
    iflag = 2 &&   linear interpolation is used between points
 && iflag = 1 &&   stepfunction for mass rate

  t = 51732.  51840.  52250.  52300.  54972.  55008. 55584.  && s
      55620.  59148.  59220.  59472.  59508.

mass = 0.     0.04424  0.0474   0.0     0.0   0.0632 0.0632  && kg/s
       0.     0.0     0.04345  0.04345 0.0

temp = 287.   287.   287.   287.   287.   287.   287.    && k
       287.   287.   287.   287.   287.
       eoi

    && source 4: air removal(leakage) from cell 3

    o2 = 6
 && iflag = 2 &&   linear interpolation is used between points
    iflag = 1 &&   stepfunction for mass rate

  t =    4320.   9864. 23029. 32508.    53100.  108000.    && s

mass = -0.584325e-3 -5.7645e-4 -3.528e-4 -9.43425e-5 -4.827375e-4 0.0

       eoi

    && source 5: air removal(leakage) from cell 3

    n2 = 6
 && iflag = 2 &&   linear interpolation is used between points
    iflag = 1 &&   stepfunction for mass rate

  t =    4320.   9864. 23029. 32508.    53100.  108000.    && s

mass = -2.198175e-3 -2.16855e-3 -1.3272e-3 -3.549075e-4 -1.8160125e-3
                                            0.0
       eoi
&&    --------------- heat structures --------------

 struc
&&  structure (3,1)
&&  lower inner cylinder
&&  no. 23 of Tab. 3b
```

```
   name= struc233 type= wall   shape= slab
   tunif= 298.0   slarea=17.8  nslab= 5      chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.28
   && no. of cell connected to
    bcouter   icell  = 8
    && structure no. in this cell
    strnum  = 3 , 1.e20    eoi
   eoi
&&  structure (3,2)
&&  lower inner cylinder
&&  no. 24 of Tab. 3b
   name= struc243 type= wall   shape= slab
   tunif= 298.0   slarea=17.8  nslab= 5      chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.28
   && no. of cell connected to
    bcouter   icell  = 6
    && structure no. in this cell
    strnum  = 3 , 1.e20    eoi
   eoi
&&  structure (3,3)
&&  lower inner cylinder
&&  no. 25 of Tab. 3b
   name= struc253 type= wall   shape= slab
   tunif= 298.0   slarea= 3.2  nslab= 5      chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.265
   && no. of cell connected to
    bcouter   icell  = 4
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&&  structure (3,4)
&&  lower, middle inner cylinder; mezzanine central floor
&&  no. 48 of Tab. 3b
   name= struc483 type= roof   shape= slab
   tunif= 298.0   slarea= 7.0  nslab= 5      chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter   icell  = 1
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&&  structure (3,5)
&&  lower, middle inner cylinder; mezzanine central roof
&&  no. 49 of Tab. 3b
   name= struc493  type= roof   shape= slab
   tunif= 298.0   slarea= 2.0  nslab= 3      chrlen= 5.
   compound=  ss    ss    ss
   x =      0.0  0.001 0.003  0.005
   && no. of cell connected to
```

```
    bcouter    icell = 1
    && structure no. in this cell
    strnum = 7 , 1.e20     eoi
   eoi
&& structure (3,6)
&& lower, middle inner cylinder; mezzanine central roof
&& no. 50 of Tab. 3b
   name= struc503  type= roof   shape= slab
   tunif= 298.0   slarea= 1.3  nslab= 3      chrlen= 5.
   compound=   ss    ss    ss
   x =      0.0  0.001 0.003  0.005
   && no. of cell connected to
    bcouter    icell = 1
    && structure no. in this cell
    strnum = 8 , 1.e20     eoi
   eoi
&& structure (3,7)
&& basemat, center (sump region)
&& no. 16 of Tab. 3b
   name= str16-03 type= floor   shape= slab
   tunif= 295.0   slarea= 11.1  nslab= 12     chrlen= 5.
   compound= conc   conc  conc  conc  conc  conc  conc
             conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.10  0.20  0.35  0.5   0.7
           0.8  1.1   1.5   1.9   2.25
   eoi

  condense

   aerosol  source=1               && siccamas input
     h2ol=2
     iflag=1  &&    step function
     t=     0.     108000.
     mass=  1.e-6   1.e-6

  ht-tran   on   && atmosphere to structures
            off  && lower cell to substructure
            on   && interlayer in lower cell
            on   && lower cell to upper cell
            on   && pool-to-structure radiative transfer

 rad-heat
  emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi

 && with  lower cell
low-cell
  geometry   11. && floor area, about 350cm thick concrete
                 && i modelled 3.1m
    bc  283.    && basemat boundary condition temperature
```

```
  interm   lay-name = conc5    temp = 283.
    compos=1 conc =    42240.            && ca. 1.6m dick
  eoi
  interm   lay-name = conc4    temp = 283.
    compos=1 conc =    21120.            && ca. 0.8m dick
  eoi
  interm   lay-name = conc3    temp = 283.
    compos=1 conc =    10560.            && ca. 0.4m dick
  eoi
  interm  lay-name = conc2     temp = 283.
    compos=1 conc =     5280.            && ca. 0.2m dick
  eoi
  interm   lay-name = conc1    temp = 283.
  &&
    compos=1 conc =     2640. && mass in kg; ca. 0.1m dick
  eoi
  pool          temp  = 283.
    compos=1     h2ol  = 0.1  && one material: compos = 1
                          && water, mass(kg) initially
    physics
      boil            && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool

    eoi    &&   end of physics
  eoi      &&   end of pool
eoi        &&   end of lower cell
&& ----------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 4   && with sump
control
 nhtm    =  11   && no of heat transfer structures
 mxslab  =  20   && "  "  nodes in any  "
 nsopl   =   4  && "  "  external sources to lower cell layers
 nsppl   =  10   && max. no of entries in lower cell source tables
 nsoatm  =   2   && no. of external sources to upper cell atmosphere
 nspatm  =  10   && max. no of entries in atmosphere source tables
 jint    =   5  && no of intermediate layers in lower cell
 jpool   =   1   && 1 if pool layer is used
 numtbc  =    4  && no of cell level tables
 maxtbc  =    8  && max. no of any cell level table
eoi

title
--- inner ring segment below dome R4 = R4.1 + R4.2

geometry   14.  6.1 && free initial atmosphere volume; heightdiff.
   atmos = 2          && no of materials
    tgas = 298.
    pgas = 1.0130e5
    molefrac  n2 = 0.79  o2 = 0.21
```

```
eoi

source = 2

 && source 1: air removal(leakage) from cell 4
 o2 = 6
&& iflag = 2 &&  linear interpolation is used between points
 iflag = 1 &&  stepfunction for mass rate

 t = 4320.   9864.  23029. 32508.  53100. 108000.  && s

mass = -2.921625e-4 -2.88225e-4 -1.764e-4 -4.717125e-5 -2.4136875e-4
        0.0
    eoi

 && source 2: air removal(leakage) from cell 4
 n2 = 6
&& iflag = 2 &&  linear interpolation is used between points
 iflag = 1 &&  stepfunction for mass rate

 t = 4320.   9864.  23029. 32508.  53100. 108000.  && s

mass = -1.0990875e-3 -1.084275e-3 -6.636e-4 -1.7745375e-4 -9.0800625e-4
        0.0
    eoi

&&   --------------- heat structures --------------

 struc
&&  structure (4,1)
&&  upper middle cylinder
&&  no. 22 of Tab. 3b
   name= struc224 type= wall   shape= slab
   tunif= 298.0   slarea= 6.2  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 9
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&&  structure (4,2)
&&  vertical partition R4/R5
&&  no. 41 of Tab. 3b
   name= struc414  type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 5
    && structure no. in this cell
    strnum = 7 , 1.e20    eoi
   eoi
```

```
&& structure (4,3)
&& vertical partition R4/R7
&& no. 42 of Tab. 3b
   name= struc424  type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter   icell  = 7
    && structure no. in this cell
    strnum  = 7 , 1.e20    eoi
   eoi
&& structure (4,4)
&& vertical partition R4/R6
&& no. 43 of Tab. 3b
   name= struc434  type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter   icell  = 6
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&& structure (4,5)
&& vertical partition R4/R8
&& no. 44 of Tab. 3b
   name= struc444  type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter   icell  = 8
    && structure no. in this cell
    strnum  = 6 , 1.e20    eoi
   eoi
&& structure (4,6)
&& lower inner cylinder
&& no. 25 of Tab. 3b
   name= struc254 type= wall   shape= slab
   tunif= 298.0   slarea= 3.2  nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.15  0.265
   && no. of cell connected to
    bcouter   icell  = 3
    && structure no. in this cell
    strnum  = 3 , 1.e20    eoi
   eoi
&& structure (4,7)
&& middle of middle inner cylinder
&& no. 28 of Tab. 3b
   name= struc284  type= wall   shape= slab
   tunif= 298.0   slarea= 2.2  nslab= 6      chrlen= 5.
```

```
    compound = conc  conc conc conc conc  conc
    x =      0.0 0.01 0.04 0.10 0.2  0.3 0.4
    && no. of cell connected to
     bcouter   icell = 1
     && structure no. in this cell
     strnum = 3 , 1.e20    eoi
    eoi
&&  structure (4,8)
&&  lower middle cylinder
&&  no. 19 of Tab. 3b
    name = strc194 type = wall   shape = slab
    tunif = 295.0   slarea = 4.8  nslab = 5     chrlen = 5.
    compound = conc  conc conc conc conc
    x =      0.0 0.01 0.04 0.07 0.11 0.15
    && no. of cell connected to
     bcouter   icell = 10
     && structure no. in this cell
     strnum = 3 , 1.e20    eoi
    eoi
&&  structure (4,9)
&&  upper inner cylinder
&&  no. 33 of Tab. 3b
    name = struc334 type = wall   shape = slab
    tunif = 298.0   slarea = 2.3  nslab = 5     chrlen = 5.
    compound = conc  conc conc conc conc
    x =      0.0 0.01 0.04 0.08 0.13 0.185
    && no. of cell connected to
     bcouter   icell = 2
     && structure no. in this cell
     strnum = 3 , 1.e20    eoi
    eoi
&&  structure (4,10)
&&  basemat, second ring
&&  no. 12 of Tab. 3b
    name = str12-04 type = floor  shape = slab
    tunif = 295.0   slarea =  2.0 nslab = 13    chrlen = 5.
    compound = conc  conc conc conc conc conc conc
            conc  conc conc conc conc conc
    x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
           0.8 1.1  1.5  2.0  2.7  3.55
    eoi
&&  structure (4,11)
&&  basemat, third ring (sump region)
&&  no. 15 of Tab. 3b
    name = str15-04 type = floor  shape = slab
    tunif = 295.0   slarea =  1.2 nslab = 12    chrlen = 5.
    compound = conc  conc conc conc conc conc conc
            conc  conc conc conc conc
    x =      0.0 0.01 0.04 0.10 0.20 0.35 0.5  0.7
           0.8 1.1  1.5  2.0  2.55
    eoi

 condense
```

```
      aerosol   1   h2ol  0.001

    ht-tran   on   && atmosphere to structures
              off  && lower cell to substructure
              on   && interlayer in lower cell
              on   && lower cell to upper cell
              on   && pool-to-structure radiative transfer


 rad-heat
  emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94
     && same no. as nhtm plus 1 if pool is specified
     kmx 1.0
     gaswal 2.5
    eoi

  && with  lower cell
 low-cell
    geometry    1. && floor area, about 250cm thick concrete
                && i modelled 3.1m
       bc  283.    && basemat boundary condition temperature

    interm   lay-name = conc5    temp  = 283.
       compos=1 conc =     3840.            && ca. 1.6m dick
    eoi
    interm   lay-name = conc4    temp  = 283.
       compos=1 conc =      1920.           && ca. 0.8m dick
    eoi
    interm   lay-name = conc3    temp  = 283.
       compos=1 conc =      960.            && ca. 0.4m dick
    eoi
    interm  lay-name = conc2     temp  = 283.
       compos=1 conc =      480.            && ca. 0.2m dick
    eoi
    interm   lay-name = conc1    temp  = 283.
    &&
       compos=1 conc =      240. && mass in kg; ca. 0.1m dick
    eoi
    pool            temp   = 283.
       compos=1     h2ol   = 0.1  && one material: compos = 1
                           && water, mass(kg) initially
       physics
          boil             && activates pool boiling model
          && settle  && allows direct aerosol settling onto pool

       eoi    &&   end of physics
     eoi      &&   end of pool
  eoi         &&   end of lower cell
  && ------------------------------------------------------

 && &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
```

```
cell 5    && no sump
        && cell with steam injection
 control
  nhtm     =   7   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
    nspatm   =  35   && max. no of entries in atmosphere source tables
    nsoatm   =   5   && no of external sources to upper cell atmosphere
    nsoaer   =   1   && no of external aerosol sources
    nspaer   =  10   && max. no of entries in aerosol source tables
    naensy   =   1   && no of separate eng. systems
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- cell between cells 6 and 11 && only one line is allowed

 geometry    41. 2.45  && free initial atmosphere volume; height
   atmos = 2           && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac  n2 = 0.79 o2 = 0.21
  && satrat
  && massfrac
  && moles
  && masses
   eoi
  && source = nso && no. of source tables to follow, s.S. 3-120ff
 source = 5

  && source 1
     h2ov = 35
     iflag = 2 &&   linear interpolation is used between points
  && iflag = 1 &&   stepfunction for mass rate
  && vapour and  enthalpy rates according to tab. 6

    t = 4068.   4320.   5400.   5436.   7200.   7920.   8712.  && s
        10296.  12420.  13104.  16092.  16848.  19440.  20988.
        23796.  30996.  31140.  38160.  52020.  52200.  57780.
        57960.  61560.  61920.  65520.  65628.  81720.  81797.
        83088.  83160.  90864   91008.  92520. 108108. 108180.
 mass = 0.     0.4     0.375   0.310   0.305   0.420   0.280  && kg/s
        0.362   0.367   0.423   0.423   0.369   0.380   0.358
        0.358   0.279   0.262   0.205   0.145   0.0     0.0
        0.033   0.033   0.124   0.120   0.0     0.0     0.122
        0.122   0.0     0.0     0.130   0.135   0.135   0.0
enth = 2.680e6 2.680e6 2.703e6 2.703e6 2.696e6 2.714e6 2.714e6 && J/kg
        2.716e6 2.720e6 2.730e6 2.730e6 2.728e6 2.728e6 2.728e6
        2.728e6 2.728e6 2.728e6 2.728e6 2.722e6 2.722e6 2.686e6
        2.686e6 2.686e6 2.686e6 2.709e6 2.709e6 2.693e6 2.693e6
        2.700e6 2.700e6 2.746e6 2.699e6 2.712e6 2.715e6 2.715e6
        eoi
```

```
    && source 2
    && air injection rates to cell 5
    o2 =  9
    iflag = 2 &&  linear interpolation is used between points
 && iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t = 61920. 62028. 62748. 63756. 63864. 64296. 64332. && s
      65592. 65628.

 mass = 0.0  0.02268  0.02268 0.02268 0.02268 0.02268 0.02268
      0.02268 0.0

 temp = 383.   523.   567.   564.   517.   517.   548.   && k
      529.   283.
      eoi

    && source 3
    && air injection rates to cell 5
    n2 =  9
    iflag = 2 &&  linear interpolation is used between points
 && iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t = 61920. 62028. 62748. 63756. 63864. 64296. 64332. && s
      65592. 65628.

 mass = 0.0  0.08532  0.08532 0.08532 0.08532 0.08532 0.08532
      0.08532 0.0

 temp = 383.   523.   567.   564.   517.   517.   548.   && k
      529.   283.
      eoi

    && source 4
    && air injection rates to cell 5
    o2 =  3
 && iflag = 2 &&  linear interpolation is used between points
    iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

   t =  0.0  82046.  83424.

 mass =  0.0  0.02268  0.0

 temp =  383.   531.   383.
      eoi

    && source 5
    && air injection rates to cell 5
```

```
    n2 =  3
  && iflag = 2 &&  linear interpolation is used between points
     iflag = 1 &&  stepfunction for mass rate

&& the following table refers to Tab. 7

    t =  0.0   82046.  83424.

 mass =  0.0   0.08532  0.0

 temp =  383.   531.   383.
      eoi

 &&   -------------- heat structures -------------

 struc
 && structure (5,1)
 && upper middle cylinder
 && no. 21 of Tab. 3b
    name= struc215  type= wall   shape= slab
    tunif= 298.0   slarea=36.8  nslab= 5     chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter   icell = 9
     && structure no. in this cell
     strnum = 2 , 1.e20    eoi
    eoi
 && structure (5,2)
 && upper middle cylinder, mezzanine floor (sump not modelled)
 && no. 35 of Tab. 3b
    name= struc355  type= floor  shape= slab
    tunif= 298.0   slarea=12.9  nslab= 5     chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.08  0.12  0.175
    && no. of cell connected to
     bcouter   icell = 6
     && structure no. in this cell
     strnum = 5 , 1.e20    eoi
    eoi
 && structure (5,3)
 && upper inner cylinder, vertical partition
 && no. 39 of Tab. 3b
    name= struc395  type= wall   shape= slab
    tunif= 298.0   slarea= 4.0  nslab= 5     chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =      0.0  0.01  0.04  0.06  0.09  0.125
    && no. of cell connected to
     bcouter   icell = 7
     && structure no. in this cell
     strnum = 4 , 1.e20    eoi
    eoi
 && structure (5,4)
```

```
&& upper, middle inner cylinder
&& no. 30 of Tab. 3b
   name= struc305 type= wall   shape= slab
   tunif= 298.0   slarea= 5.9  nslab= 6     chrlen= 5.
   compound= conc  conc conc conc conc  conc
   x =     0.0 0.01 0.04 0.10 0.2  0.3 0.4
   && no. of cell connected to
    bcouter   icell = 1
    && structure no. in this cell
    strnum  = 5 , 1.e20    eoi
   eoi
&& structure (5,5)
&& upper inner cylinder
&& no. 32 of Tab. 3b
   name= struc325 type= wall   shape= slab
   tunif= 298.0   slarea=13.9  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.08 0.13 0.185
   && no. of cell connected to
    bcouter   icell = 2
    && structure no. in this cell
    strnum  = 2 , 1.e20    eoi
   eoi
&& structure (5,6)
&& upper roof
&& no. 37 of Tab. 3b
   name= struc375 type= roof   shape= slab
   tunif= 298.0   slarea=17.5  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.08 0.13 0.185
   && no. of cell connected to
    bcouter   icell = 11
    && structure no. in this cell
    strnum  = 2 , 1.e20    eoi
   eoi
&& structure (5,7)
&& vertical partition R5/R4
&& no. 41 of Tab. 3b
   name= struc415 type= wall   shape= slab
   tunif= 298.0   slarea= 4.4  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.06 0.09 0.125
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum  = 2 , 1.e20    eoi
   eoi

 condense

    aerosol
      source = 1
      naoh =4  iflag= 1  && step function
```

```
  t=     63720. 65448.  82512. 83088.
 mass= 1.28e-3    0.0    1.25e-3  0.0

 ht-tran   on   && atmosphere to structures
           off  && lower cell to substructure
           off  && interlayer in lower cell
           off  && lower cell to upper cell
           off  && pool-to-structure radiative transfer

&& no lower cell

    overflow 6

rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

 cell 6    && with sump
 control
  nhtm     =   8   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
   nsopl   =   4   && "  "  external sources to lower cell layers
   nsppl   =  10   && max. no of entries in lower cell source tables
   jint    =   5   && no of intermediate layers in lower cell
   jpool   =   1   && 1 if pool layer is used
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- below cell 5

 geometry   41. 2.95 && free initial atmosphere volume; heightdiff.
   atmos = 2           && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac    n2 = 0.79 o2 = 0.21
   eoi
  && source = nso && no. of source tables to follow, s.S. 3-120ff
     && eoi

&&    --------------- heat structures --------------

 struc
&&  structure (6,1)
&&  lower middle cylinder
&&  no. 18 of Tab. 3b
   name= struc186 type= wall    shape= slab
```

```
    tunif= 298.0   slarea=28.4  nslab= 5      chrlen= 5.
    compound= conc  conc conc conc conc
    x =       0.0 0.01 0.04 0.07 0.11 0.15
    && no. of cell connected to
     bcouter   icell = 10
     && structure no. in this cell
     strnum = 2 , 1.e20    eoi
    eoi
&&  structure (6,2)
&&  vertical partition R6/R8
&&  no. 40 of Tab. 3b
    name= struc406  type= wall   shape= slab
    tunif= 298.0   slarea= 4.1  nslab= 5     chrlen= 5.
    compound= conc  conc conc conc conc
    x =       0.0 0.01 0.04 0.06 0.09 0.125
    && no. of cell connected to
     bcouter   icell = 8
     && structure no. in this cell
     strnum = 2 , 1.e20    eoi
    eoi
&&  structure (6,3)
&&  lower inner cylinder
&&  no. 24 of Tab. 3b
    name= struc246 type= wall   shape= slab
    tunif= 298.0   slarea=17.8  nslab= 5      chrlen= 5.
    compound= conc  conc conc conc conc
    x =       0.0 0.01 0.04 0.08 0.15 0.28
    && no. of cell connected to
     bcouter   icell = 3
     && structure no. in this cell
     strnum = 2 , 1.e20    eoi
    eoi
&&  structure (6,4)
&&  lower, middle inner cylinder
&&  no. 27 of Tab. 3b
    name= struc276  type= wall   shape= slab
    tunif= 298.0   slarea= 7.2  nslab= 6     chrlen= 5.
    compound= conc  conc conc conc conc  conc
    x =       0.0 0.01 0.04 0.10 0.2  0.3 0.4
    && no. of cell connected to
     bcouter   icell = 1
     && structure no. in this cell
     strnum = 2 , 1.e20    eoi
    eoi
&&  structure (6,5)
&&  upper middle cylinder, mezzanine floor (sump not modelled)
&&  no. 35 of Tab. 3b
    name= struc356  type= roof   shape= slab
    tunif= 298.0   slarea=12.9  nslab= 5      chrlen= 5.
    compound= conc  conc conc conc conc
    x =       0.0 0.01 0.04 0.08 0.12 0.175
    && no. of cell connected to
     bcouter   icell = 5
```

```
     && structure no. in this cell
     strnum  =  2 , 1.e20     eoi
    eoi
 &&  structure (6,6)
 &&  vertical partition R4/R6
 &&  no. 43 of Tab. 3b
    name= struc436  type= wall    shape= slab
    tunif= 298.0    slarea= 4.4   nslab= 5       chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.06  0.09  0.125
    && no. of cell connected to
     bcouter    icell  =  4
     && structure no. in this cell
     strnum  =  4 , 1.e20     eoi
    eoi
 &&  structure (6,7)
 &&  basemat, second ring
 &&  no. 11 of Tab. 3b
    name= str11-06 type= floor   shape= slab
    tunif= 295.0    slarea= 18.8  nslab= 13      chrlen= 5.
    compound= conc   conc  conc  conc  conc  conc  conc
            conc   conc  conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.10  0.20  0.35  0.5   0.7
            0.8  1.1   1.5   2.0   2.7   3.55
    eoi
 &&  structure (6,8)
 &&  basemat, third ring (sump region)
 &&  no. 14 of Tab. 3b
    name= str14-06 type= floor   shape= slab
    tunif= 295.0    slarea=  7.7  nslab= 12      chrlen= 5.
    compound= conc   conc  conc  conc  conc  conc  conc
            conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.10  0.20  0.35  0.5   0.7
            0.8  1.1   1.5   2.0   2.55
    eoi

  condense

     aerosol   1   h2ol  0.001

  ht-tran   on    && atmosphere to structures
            off  && lower cell to substructure
            on   && interlayer in lower cell
            on   && lower cell to upper cell
            on   && pool-to-structure radiative transfer


rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi
```

```
 && with  lower cell
low-cell
   geometry    8. && floor area, between 250cm and 3.5m thick
               && i modelled 3.1m
      bc  283.    && basemat boundary condition temperature

   interm  lay-name = conc5   temp = 283.
      compos=1 conc =    30720.          && ca. 1.6m dick
   eoi
   interm  lay-name = conc4   temp = 283.
      compos=1 conc =    15360.          && ca. 0.8m dick
   eoi
   interm  lay-name = conc3   temp = 283.
      compos=1 conc =     7680.          && ca. 0.4m dick
   eoi
   interm lay-name = conc2    temp = 283.
      compos=1 conc =     3840.          && ca. 0.2m dick
   eoi
   interm  lay-name = conc1   temp = 283.
   &&
      compos=1 conc =     1920. && mass in kg; ca. 0.1m dick
   eoi
   pool         temp  = 283.
      compos=1     h2ol  = 0.1  && one material: compos = 1
                          && water, mass(kg) initially
      physics
         boil            && activates pool boiling model
         && settle  && allows direct aerosol settling onto pool

      eoi    &&   end of physics
   eoi       &&   end of pool
 eoi         &&   end of lower cell
 && --------------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 7    && no sump
 control
  nhtm     =   7   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
  naensy   =   1   && no of separate eng. systems
  numtbc   =    4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- cell between cells 8 and 11

 geometry    41. 2.45  && free initial atmosphere volume; height
    atmos = 2          && no of materials
      tgas = 298.
      pgas = 1.0130e5
```

```
   molefrac   n2 = 0.79 o2 = 0.21
  eoi
 && source = nso && no. of source tables to follow, s.S. 3-120ff
   && eoi

&&   --------------- heat structures --------------

 struc
&&  structure (7,1)
&&  upper middle cylinder
&&  no. 20 of Tab. 3b
    name= struc207  type= wall    shape= slab
    tunif= 298.0    slarea=36.8   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter    icell = 9
     && structure no. in this cell
     strnum  = 1 , 1.e20     eoi
    eoi
&&  structure (7,2)
&&  upper middle cylinder, mezzanine floor (sump not modelled)
&&  no. 34 of Tab. 3b
    name= struc347  type= floor   shape= slab
    tunif= 298.0    slarea=14.9   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.08  0.12  0.175
    && no. of cell connected to
     bcouter    icell = 8
     && structure no. in this cell
     strnum  = 5 , 1.e20     eoi
    eoi
&&  structure (7,3)
&&  upper ceiling
&&  no. 36 of Tab. 3b
    name= struc367  type= roof    shape= slab
    tunif= 298.0    slarea=17.3   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.08  0.12  0.175
    && no. of cell connected to
     bcouter    icell = 11
     && structure no. in this cell
     strnum  = 1 , 1.e20     eoi
    eoi
&&  structure (7,4)
&&  upper inner cylinder, vertical partition R5/R7
&&  no. 39 of Tab. 3b
    name= struc397  type= wall    shape= slab
    tunif= 298.0    slarea= 4.0   nslab= 5      chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.06  0.09  0.125
    && no. of cell connected to
     bcouter    icell = 5
```

```
    && structure no. in this cell
    strnum  =  3 , 1.e20      eoi
   eoi
&&  structure (7,5)
&&  upper, middle inner cylinder
&&  no. 29 of Tab. 3b
   name= struc297  type= wall    shape= slab
   tunif= 298.0    slarea= 5.9   nslab= 6       chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =        0.0  0.01  0.04  0.10  0.2   0.3  0.4
   && no. of cell connected to
    bcouter    icell  =  1
    && structure no. in this cell
    strnum  =  4 , 1.e20      eoi
   eoi
&&  structure (7,6)
&&  upper inner cylinder
&&  no. 31 of Tab. 3b
   name= struc317 type= wall    shape= slab
   tunif= 298.0    slarea=13.9   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter    icell  =  2
    && structure no. in this cell
    strnum  =  1 , 1.e20      eoi
   eoi
&&  structure (7,7)
&&  vertical partition R4/R7
&&  no. 42 of Tab. 3b
   name= struc427  type= wall    shape= slab
   tunif= 298.0    slarea= 4.4   nslab= 5       chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =        0.0  0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter    icell  =  4
    && structure no. in this cell
    strnum  =  3 , 1.e20      eoi
   eoi

 condense

    aerosol  1   h2ol  0.001

 ht-tran   on   && atmosphere to structures
           off  && lower cell to substructure
           off  && interlayer in lower cell
           off  && lower cell to upper cell
           off  && pool-to-structure radiative transfer

&& no lower cell

     overflow  8
```

```
rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi

&& &&&&&&&&&&&&&&&&&&&&&&&&&&

 cell 8    && with sump
 control
  nhtm     =   8   && no of heat transfer structures
  mxslab   =  20   && "  "  nodes in any  "
    nsopl    =   4   && "  "  external sources to lower cell layers
    nsppl    =  10   && max. no of entries in lower cell source tables
    nspatm   =  10   && max. no of entries in atmosphere source tables
    jint     =   5   && no of intermediate layers in lower cell
    jpool    =   1   && 1 if pool layer is used
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- below cell 7

 geometry   41. 2.95 && free initial atmosphere volume; heightdiff.
   atmos = 2          && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac   n2 = 0.79 o2 = 0.21
   eoi

 &&    --------------- heat structures --------------

  struc
 &&  structure (8,1)
 &&  lower middle cylinder
 &&  no. 17 of Tab. 3b
    name= struc178 type= wall    shape= slab
    tunif= 298.0    slarea=28.4   nslab= 5       chrlen= 5.
    compound= conc   conc  conc  conc  conc
    x =       0.0  0.01  0.04  0.07  0.11  0.15
    && no. of cell connected to
     bcouter    icell = 10
     && structure no. in this cell
     strnum  = 1 , 1.e20     eoi
    eoi
 &&  structure (8,2)
 &&  vertical partition R6/R8
 &&  no. 40 of Tab. 3b
    name= struc408  type= wall    shape= slab
    tunif= 298.0    slarea= 4.1   nslab= 5       chrlen= 5.
```

```
   compound= conc   conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter    icell  =  6
    && structure no. in this cell
    strnum  =  2 , 1.e20     eoi
   eoi
&&  structure (8,3)
&&  lower inner cylinder
&&  no. 23 of Tab. 3b
   name= struc238 type= wall    shape= slab
   tunif= 298.0    slarea=17.8   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.08  0.15  0.28
   && no. of cell connected to
    bcouter    icell  =  3
    && structure no. in this cell
    strnum  =  1 , 1.e20     eoi
   eoi
&&  structure (8,4)
&&  lower, middle inner cylinder
&&  no. 26 of Tab. 3b
   name= struc268  type= wall    shape= slab
   tunif= 298.0    slarea= 7.2   nslab= 6      chrlen= 5.
   compound= conc   conc  conc  conc  conc   conc
   x =      0.0 0.01  0.04  0.10  0.2   0.3  0.4
   && no. of cell connected to
    bcouter    icell  =  1
    && structure no. in this cell
    strnum  =  1 , 1.e20     eoi
   eoi
&&  structure (8,5)
&&  lower middle cylinder, mezzanine floor (sump not modelled)
&&  no. 34 of Tab. 3b
   name= struc348  type= roof    shape= slab
   tunif= 298.0    slarea=14.9   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.08  0.12  0.175
   && no. of cell connected to
    bcouter    icell  =  7
    && structure no. in this cell
    strnum  =  2 , 1.e20     eoi
   eoi
&&  structure (8,6)
&&  vertical partition R4/R8
&&  no. 44 of Tab. 3b
   name= struc448  type= wall    shape= slab
   tunif= 298.0    slarea= 4.4   nslab= 5      chrlen= 5.
   compound= conc   conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.06  0.09  0.125
   && no. of cell connected to
    bcouter    icell  =  4
    && structure no. in this cell
```

```
    strnum = 5 , 1.e20    eoi
   eoi
&& structure (8,7)
&& basemat, second ring
&& no. 10 of Tab. 3b
   name= str10-08 type= floor  shape= slab
   tunif= 295.0   slarea= 18.8  nslab= 13    chrlen= 5.
   compound= conc  conc  conc  conc  conc  conc  conc
          conc  conc  conc  conc  conc  conc
   x =     0.0  0.01  0.04  0.10  0.20  0.35  0.5  0.7
         0.8  1.1  1.5  2.0  2.7  3.55
   eoi
&& structure (8,8)
&& basemat, third ring (sump region)
&& no. 13 of Tab. 3b
   name= str13-08 type= floor  shape= slab
   tunif= 295.0   slarea=  7.7  nslab= 12    chrlen= 5.
   compound= conc  conc  conc  conc  conc  conc  conc
          conc  conc  conc  conc  conc
   x =     0.0  0.01  0.04  0.10  0.20  0.35  0.5  0.7
         0.8  1.1  1.5  2.0  2.55
   eoi

  condense

   aerosol  1  h2ol  0.001

  ht-tran  on  && atmosphere to structures
          off  && lower cell to substructure
          on   && interlayer in lower cell
          on   && lower cell to upper cell
          on   && pool-to-structure radiative transfer


rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi

 && with  lower cell
low-cell
  geometry   8. && floor area, between 250cm and 3.5m thick
             && i modelled 3.1m
    bc  283.   && basemat boundary condition temperature

  interm  lay-name = conc5   temp = 283.
    compos=1 conc =   30720.        && ca. 1.6m dick
  eoi
  interm  lay-name = conc4   temp = 283.
    compos=1 conc =   15360.        && ca. 0.8m dick
  eoi
```

```
  interm   lay-name = conc3    temp = 283.
    compos=1 conc =      7680.           && ca. 0.4m dick
  eoi
  interm  lay-name = conc2    temp = 283.
    compos=1 conc =      3840.           && ca. 0.2m dick
  eoi
  interm   lay-name = conc1    temp = 283.
  &&
    compos=1 conc =      1920. && mass in kg; ca. 0.1m dick
  eoi
  pool            temp  = 283.
    compos=1     h2ol  = 0.1  && one material: compos = 1
                         && water, mass(kg) initially
    physics
      boil           && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool

    eoi    &&   end of physics
  eoi      &&   end of pool
eoi        &&   end of lower cell
&& ------------------------------------------------------

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 9    && no sump
          && gets all condensed water of dome and puts it to
          && sump in cell 10 via overflow.

control
 nhtm     =   5   && no of heat transfer structures
 mxslab   =  25   && "  " nodes in any  "
 nspatm   =  10   && max. no of entries in atmosphere source tables
   naensy  =   1   && no of separate eng. systems
 numtbc   =   4   && no of cell level tables
 maxtbc   =   8   && max. no of any cell level table
eoi

title
--- upper annular ring below dome = R9.3

geometry    93. 2.9   && free initial atmosphere volume; height
   atmos = 2           && no of materials
     tgas = 295.
     pgas = 1.0130e5
     molefrac    n2 = 0.79 o2 = 0.21
   eoi

&&     --------------- heat structures --------------

 struc
&&  structure (9,1)
&&  upper middle cylinder
&&  no. 20 of Tab. 3b
```

```
   name= struc209  type= wall   shape= slab
   tunif= 298.0   slarea =36.8  nslab= 5     chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0 0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter   icell = 7
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&&  structure (9,2)
&&  upper middle cylinder
&&  no. 21 of Tab. 3b
   name= struc219  type= wall   shape= slab
   tunif= 298.0   slarea =36.8  nslab= 5     chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.07  0.11  0.15
   && no. of cell connected to
    bcouter   icell = 5
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&&  structure (9,3)
&&  upper middle cylinder
&&  no. 22 of Tab. 3b
   name= struc229  type= wall   shape= slab
   tunif= 298.0   slarea= 6.2  nslab= 5     chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.07  0.11 `0.15
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&&  structure (9,4)
&&  middle outer cylinder
&&  no. 2  of Tab. 3b
&&  correct modelling by userdef data  (1.3.96)
   name= str02-9  type= wall   shape= slab
   tunif= 295.0   slarea= 37.7  nslab= 21     chrlen= 5.
   compound= coat  coat  coat  conc  conc  conc  conc conc
       conc  conc  conc  conc  gap  gap  gap  ytong ytong
      ytong ytong ytong  ytong
   x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
        0.24  0.34  0.44  0.452 0.455 0.46  0.4722  0.48  0.5
       0.54  0.60   0.65   0.7122
   eoi
  &&  and take it as connected to environment
&&  structure (9,5)
&&  i modell it correctly by using userdef  (1.3.96)
&&  middle outer cylinder
&&  no. 3  of Tab. 3b
   name= str03-9  type= wall   shape= slab  iouter = 12
   tunif= 295.0   slarea= 66.6  nslab= 12     chrlen= 5.
```

```
    compound = coat   coat  coat   conc  conc  conc  conc conc
         conc  conc   conc  conc
    x =      0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
             0.24  0.34  0.44  0.452
    eoi

  condense

     aerosol   1   h2ol  0.001

  ht-tran   on   && atmosphere to structures
           off  && lower cell to substructure
           off  && interlayer in lower cell
           off  && lower cell to upper cell
           off  && pool-to-structure radiative transfer

 && no lower cell

     overflow  10

rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 10   && with sump
        && cell with air injection/removal
 control
  nhtm     =   5   && no of heat transfer structures
  mxslab   =  25   && "  "  nodes in any  "
   nsopl    =   4   && "  "  external sources to lower cell layers
   nsppl    =  10   && max. no of entries in lower cell source tables
   nspatm   =   10   && max. no of entries in atmosphere source tables
   nsoatm   =    4   && no of external sources to upper cell atmosphere
   jint     =   5   && no of intermediate layers in lower cell
   jpool    =   1   && 1 if pool layer is used
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- lower annular ring below dome = R9.4

 geometry   70. 2.2   && free initial atmosphere volume; height
   atmos = 2          && no of materials
     tgas = 295.
     pgas = 1.0130e5
     molefrac   n2 = 0.79 o2 = 0.21
   eoi
```

```
 source = 4
&& source slightly modified from case19 on

&& source 1: air removal and injection from/to  cell 10
   o2 = 13      && and according temperatures
   iflag = 2 &&   linear interpolation is used between points
&& iflag = 1 &&   stepfunction for mass rate

  t =  6280.   6300.  14580. 15000.                  && s
      52350.  52380.  53100. 54972. 55008.             && s
      59472.  59508.  59760. 59800.                  && s

mass = 0.0    -5.25e-3 -5.25e-3 0.0                  && kg/s
      0.0     0.0126  0.0168  0.0168 0.0             && kg/s
      0.0     0.01155     0.01155  0.0               && kg/s

temp = 287.    287.    287.    287.                  && k
      287.    287.    287.    287.  287.             && k
      287.    287.    287.    287.                   && k
   eoi

&& source 2: air removal and injection from/to  cell 10
   n2 = 13      && and according temperatures
   iflag = 2 &&   linear interpolation is used between points
&& iflag = 1 &&   stepfunction for mass rate

  t =  6280.   6300.  14580. 15000.                  && s
      52350.  52380.  53100. 54972. 55008.             && s
      59472.  59508.  59760. 59800.                  && s

mass = 0.0    -1.975e-2 -1.975e-2 0.0                && kg/s
      0.0     0.0474   0.0632 0.0632  0.0            && kg/s
      0.0     0.04345     0.04345  0.0               && kg/s

temp = 287.    287.    287.    287.                  && k
      287.    287.    287.    287.  287.             && k
      287.    287.    287.    287.                   && k
   eoi

   && source 3: air removal(leakage) from cell 10

   o2 = 6
&& iflag = 2 &&   linear interpolation is used between points
   iflag = 1 &&   stepfunction for mass rate

  t =  4320.  9864.    23029.  32508.   53100. 108000.0  && s

mass = -1.4608125e-3 -1.441125e-3 -8.82e-4 -2.358563e-4 -1.2068438e-3
             0.0
      eoi

   && source 4: air removal(leakage) from cell 10
```

```
    n2 = 6
  && iflag = 2 &&  linear interpolation is used between points
    iflag = 1 &&  stepfunction for mass rate

   t = 4320.  9864.   23029. 32508.  53100. 108000.0 && s

mass = -5.4954375e-3 -5.421375e-3 -0.003318 -8.872687e-4 -4.5400312e-3
             0.0
       eoi

&&   --------------- heat structures -------------

 struc
&& structure (10,1)
&& lower middle cylinder
&& no. 17 of Tab. 3b
   name= strc1710 type= wall   shape= slab
   tunif= 295.0   slarea=28.4  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 8
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&& structure (10,2)
&& lower middle cylinder
&& no. 18 of Tab. 3b
   name= strc1810 type= wall   shape= slab
   tunif= 295.0   slarea=28.4  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 6
    && structure no. in this cell
    strnum = 1 , 1.e20    eoi
   eoi
&& structure (10,3)
&& lower middle cylinder
&& no. 19 of Tab. 3b
   name= strc1910 type= wall   shape= slab
   tunif= 295.0   slarea= 4.8  nslab= 5     chrlen= 5.
   compound= conc  conc conc conc conc
   x =     0.0 0.01 0.04 0.07 0.11 0.15
   && no. of cell connected to
    bcouter   icell = 4
    && structure no. in this cell
    strnum = 8 , 1.e20    eoi
   eoi
&& structure (10,4)
&& correct modelling by userdef data (1.3.96)
&& lower outer cylinder
```

```
&& no. 1  of Tab. 3b
   name= str01-10 type= wall   shape= slab
   tunif= 295.0   slarea= 80.5  nslab= 21      chrlen= 5.
   compound= coat  coat  coat  conc  conc  conc  conc conc
       conc  conc  conc  conc  gap  gap  gap  ytong ytong
      ytong ytong ytong  ytong
   x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
          0.24  0.34  0.44  0.452 0.455 0.46  0.4722  0.48  0.5
         0.54  0.60  0.65  0.7122
   eoi
&& structure (10,5)
&& basemat, outer ring (sumpregion)
&& no. 9  of Tab. 3b
   name= str09-10 type= floor   shape= slab
   tunif= 295.0   slarea= 32.3  nslab= 13      chrlen= 5.
   compound= conc  conc  conc  conc  conc  conc  conc
          conc  conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.10  0.20  0.35  0.5   0.7
          0.8  1.1   1.5   2.0   2.7   3.55
   eoi

  condense

    aerosol  1   h2ol  0.001

  ht-tran  on   && atmosphere to structures
           off  && lower cell to substructure
           on   && interlayer in lower cell
           on   && lower cell to upper cell
           on   && pool-to-structure radiative transfer

rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi


 && lower cell input
low-cell
  geometry  27. && floor area, about 350cm thick concrete
                && i modelled 3.1m
     bc  283.   && basemat boundary condition temperature

  interm  lay-name = conc5   temp = 283.
    compos=1 conc =  103680.            && ca. 1.6m dick
  eoi
  interm  lay-name = conc4   temp = 283.
    compos=1 conc =   51840.            && ca. 0.8m dick
  eoi
  interm  lay-name = conc3   temp = 283.
    compos=1 conc =   25920.            && ca. 0.4m dick
```

```
  eoi
  interm  lay-name = conc2     temp = 283.
    compos=1 conc =     12960.          && ca. 0.2m dick
  eoi
  interm   lay-name = conc1    temp = 283.
  &&
    compos=1 conc =      6480. && mass in kg; ca. 0.1m dick
  eoi
  pool          temp  = 283.
    compos=1     h2ol  = 0.1  && one material: compos = 1
                           && water, mass(kg) initially
    physics
      boil             && activates pool boiling model
      && settle  && allows direct aerosol settling onto pool

    eoi    &&   end of physics
  eoi      &&   end of pool
 eoi       &&   end of lower cell
 && ------------------------------------------------------


&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&

cell 11   && no sump

 control
  nhtm     =   9   && no of heat transfer structures
  mxslab   =  25   && "  "  nodes in any  "
    nspatm   =  10   && max. no of entries in atmosphere source tables
    nsoatm   =   2   && no of external sources to upper cell atmosphere
    naensy   =   1   && no of separate eng. systems
  numtbc   =   4   && no of cell level tables
  maxtbc   =   8   && max. no of any cell level table
 eoi

 title
 --- dome = R9.1 + R9.2

 geometry  215. 3.4 && free initial atmosphere volume; heightdiff.
   atmos = 2           && no of materials
     tgas = 298.
     pgas = 1.0130e5
     molefrac    n2 = 0.79 o2 = 0.21
   eoi

   source = 2
     && source 1: air removal(leakage) from cell 11
     o2 = 6
   && iflag = 2 &&  linear interpolation is used between points
     iflag = 1 &&  stepfunction for mass rate

    t =   4320.    9864.  23029.  32508.  53100. 108000.  && s
```

```
mass = -7.791e-4   0.0    0.0    0.0   -6.4344e-4 0.0  && kg/s

     eoi

   && source 2: air removal(leakage) from cell 11
   n2 = 6
 && iflag = 2 &&  linear interpolation is used between points
   iflag = 1 &&  stepfunction for mass rate

  t =   4320.   9864.   23029.   32508.  53100. 108000.  && s

 mass =-0.0029309   0.0     0.0     0.0  -0.00242056 0.0   && kg/s

     eoi


&&    --------------- heat structures --------------

 struc
&&  structure (11,1)
&&  upper floor of dome
&&  no. 36 of Tab. 3b
   name= strc3611 type= floor  shape= slab
   tunif= 298.0   slarea=17.3  nslab= 5     chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter   icell = 7
    && structure no. in this cell
    strnum = 3 , 1.e20    eoi
   eoi
&&  structure (11,2)
&&  upper floor of dome
&&  no. 37 of Tab. 3b
   name= strc3711 type= floor  shape= slab
   tunif= 298.0   slarea=17.5  nslab= 5     chrlen= 5.
   compound= conc  conc  conc  conc  conc
   x =      0.0  0.01  0.04  0.08  0.13  0.185
   && no. of cell connected to
    bcouter   icell = 5
    && structure no. in this cell
    strnum = 6 , 1.e20    eoi
   eoi

&&  structure (11,3)
&&  i modell it correctly  (1.3.96)
&&  upper outer cylinder
&&  no. 4  of Tab. 3b
   name= str04-11 type= wall   shape= slab
   tunif= 295.0   slarea= 16.5  nslab= 21     chrlen= 5.
   compound= coat  coat  coat  conc  conc  conc  conc conc
     conc  conc  conc  conc  gap  gap  gap  ytong ytong
        ytong ytong ytong  ytong
```

```
  x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
      0.24  0.34  0.44  0.552 0.555 0.56  0.5722  0.59  0.61
        0.65  0.70   0.75   0.7922
  eoi
&&  structure (11,4)
&&  upper outer cylinder
&&  i modell it correctly   (1.3.96)
&&  no. 5  of Tab. 3b
  name= str05-11 type= wall    shape= slab
  tunif= 295.0    slarea= 29.1  nslab= 12      chrlen= 5.
  compound= coat   coat  coat   conc  conc  conc  conc conc
      conc  conc   conc  conc
  x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
        0.24  0.34  0.44  0.552
  eoi
&&  structure (11,5)
&&  upper cone
&&  i modell it correctly   (1.3.96)
&&  no. 6  of Tab. 3b
  name= str06-11 type= roof    shape= slab
  tunif= 295.0    slarea= 86.3  nslab= 17      chrlen= 5.
  compound= coat   coat  coat   conc  conc  conc  conc conc
      conc  conc   conc  conc conc  conc conc conc conc
  x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
        0.24  0.34  0.44  0.54  0.66 0.80 1.0 1.21 1.422
  eoi
&&  structure (11,6)
&&  lower cone
&&  i modell it correctly   (1.3.96)
&&  no. 46  of Tab. 3b
  name= str46-11 type= roof    shape= slab
  tunif= 295.0    slarea=  8.7  nslab= 16     chrlen= 5.
  compound= coat   coat  coat   conc  conc  conc  conc conc
      conc  conc   conc  conc conc  conc conc conc
  x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
        0.24  0.34  0.44  0.54  0.66 0.80 1.0 1.202
  eoi
&&  structure (11,7)
&&  top flange, top ring
&&  i modell it correctly   (1.3.96)
&&  no. 7  of Tab. 3b
  name= str07-11 type= roof    shape= slab
  tunif= 295.0    slarea=  7.8  nslab= 17     chrlen= 5.
  compound=  ss     ss     ss    conc  conc  conc  conc conc
    conc  conc   conc  conc  licon  licon  licon  licon licon
  x =     0.00 0.0004 0.001 0.002 0.005 0.015 0.04 0.08  0.16
     0.24  0.34   0.44   0.522  0.54   0.60   0.75   0.9 1.042
  eoi
&&  structure (11,8)
&&  top cover
&&  i modell it correctly   (1.3.96)
&&  no. 8  of Tab. 3b
  name= str08-11 type= roof    shape= slab
```

```
    tunif= 295.0    slarea= 19.0  nslab= 13      chrlen= 5.
    compound= ss     ss    ss   licon licon licon licon licon
      licon  licon  licon  licon  licon
    x =      0.00 0.0004 0.001 0.002 0.005  0.015   0.04   0.08  0.16
          0.24   0.32     0.40    0.50   0.602
    eoi
 &&  structure (11,9)
 &&  top cover
 &&  i modell it correctly  as steel and correct temp.
 &&  no. 47 of Tab. 3b
    name= str47-11 type= roof    shape= slab
    tunif= 283.0    slarea=  4.2  nslab= 4       chrlen= 5.
    compound= ss    ss    ss     ss
    x =       0.0 0.001 0.003 0.006 0.01
    eoi

  condense

     aerosol   1   h2ol  0.001

  ht-tran   on    && atmosphere to structures
            off  && lower cell to substructure
            off  && interlayer in lower cell
            off  && lower cell to upper cell
            off  && pool-to-structure radiative transfer

 && no lower cell

      overflow  10  && from case 28 on

rad-heat
 emsvt 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94 0.94
   && same no. as nhtm plus 1 if pool is specified
   kmx 1.0
   gaswal 2.5
  eoi

&& &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&

 && ------------------------ cell 12  environment
 cell 12
 control
 eoi
 title
 ------ environment ------
 geometry  1.e15 1.e15
    atmos  = 2  pgas  =  1.0130e5  tgas  = 283.
              molefrac n2  =  0.79    o2  =  0.21
    eoi
 eoi

eof
```

11. Figures

steam and aerosol release site

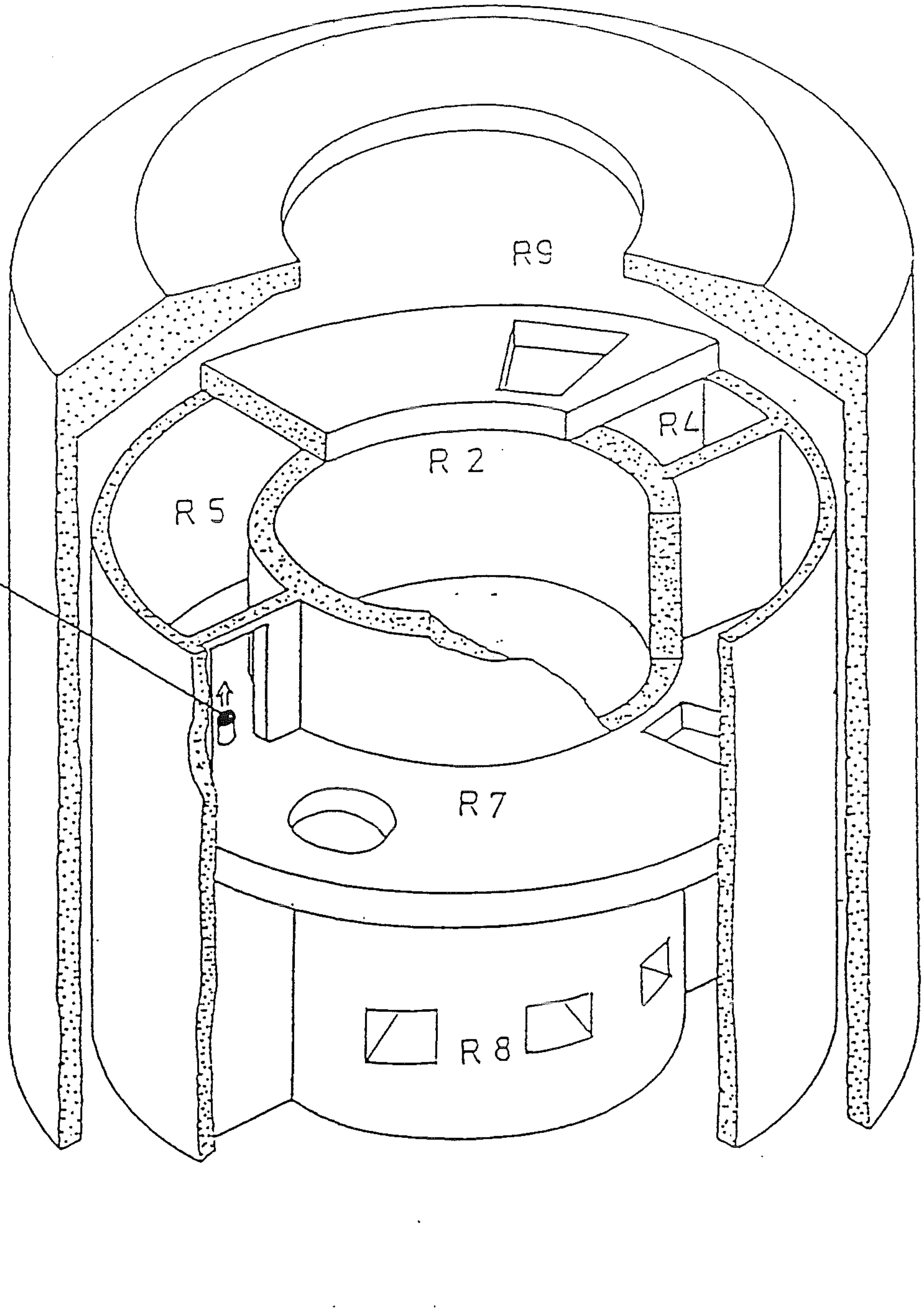


Fig. 1 **Battelle model containment ($626\ m^3$) in VANAM test configuration**

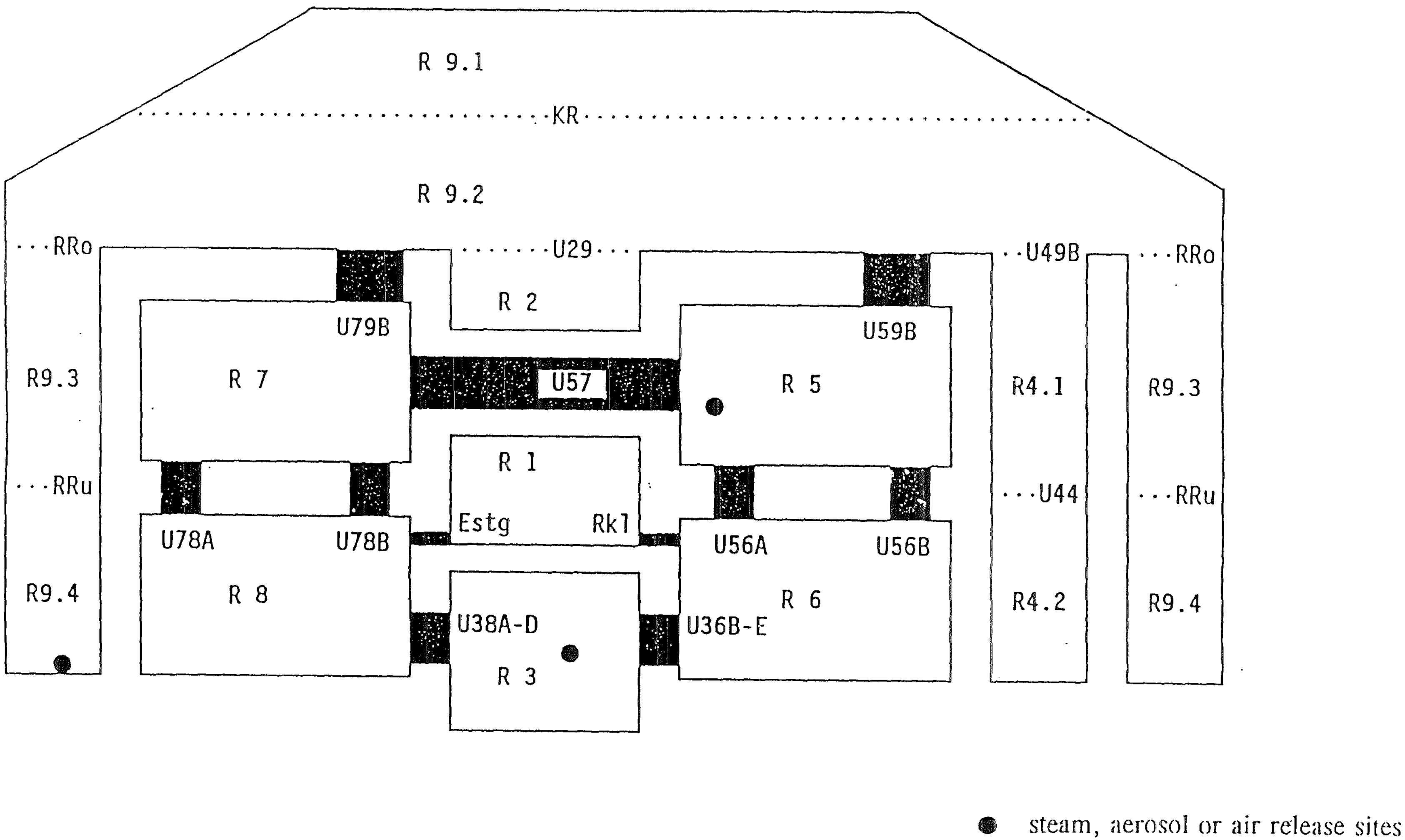


Fig. 2 VANAM test M3: Subdivision of the model containment into 13 nodes

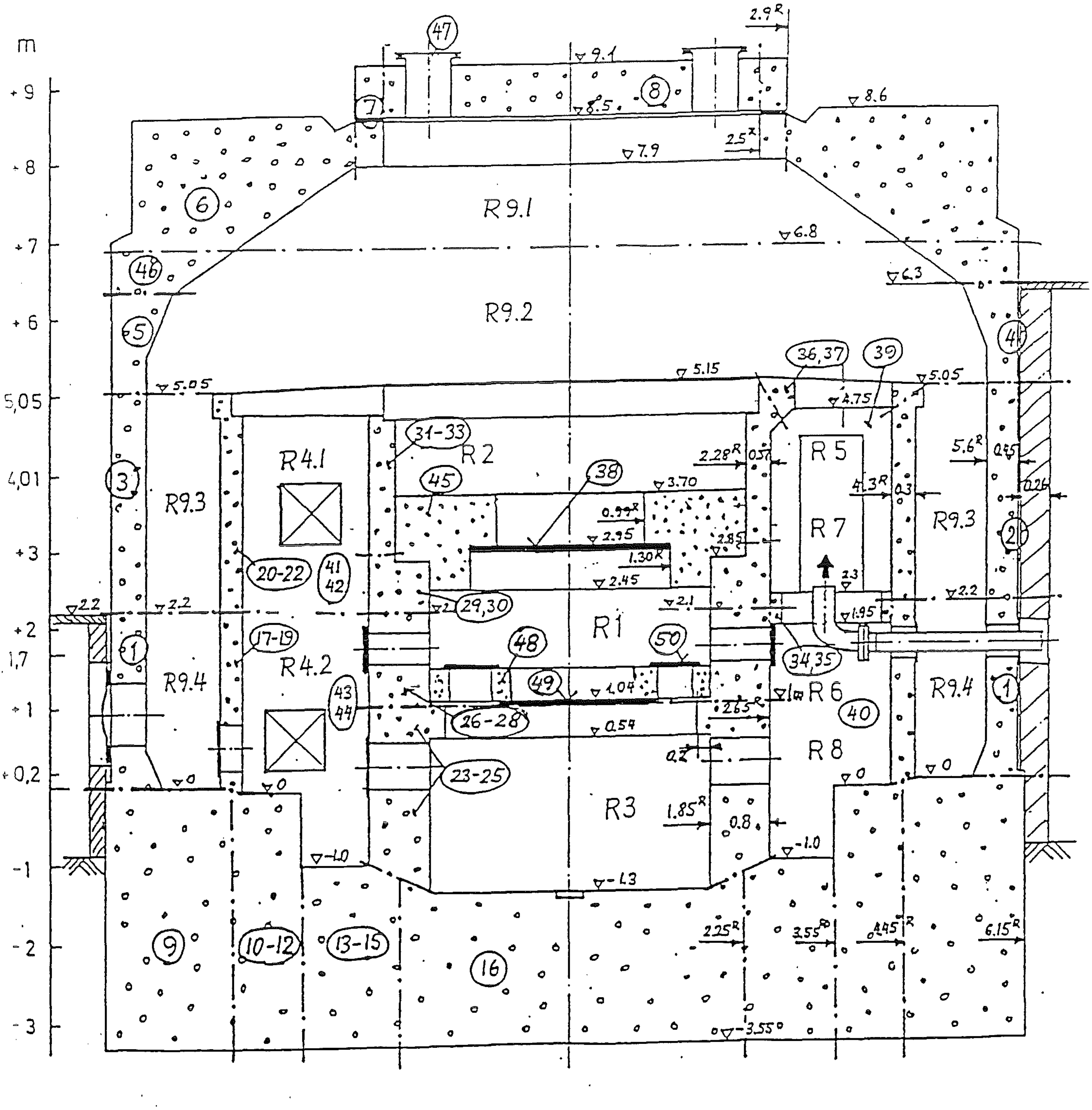


Fig. 3 , **Cross section of the Battelle model containment (VANAM tests)**
The numbers in circles refer to a subdivision of the structures according to the ISP-37 specification

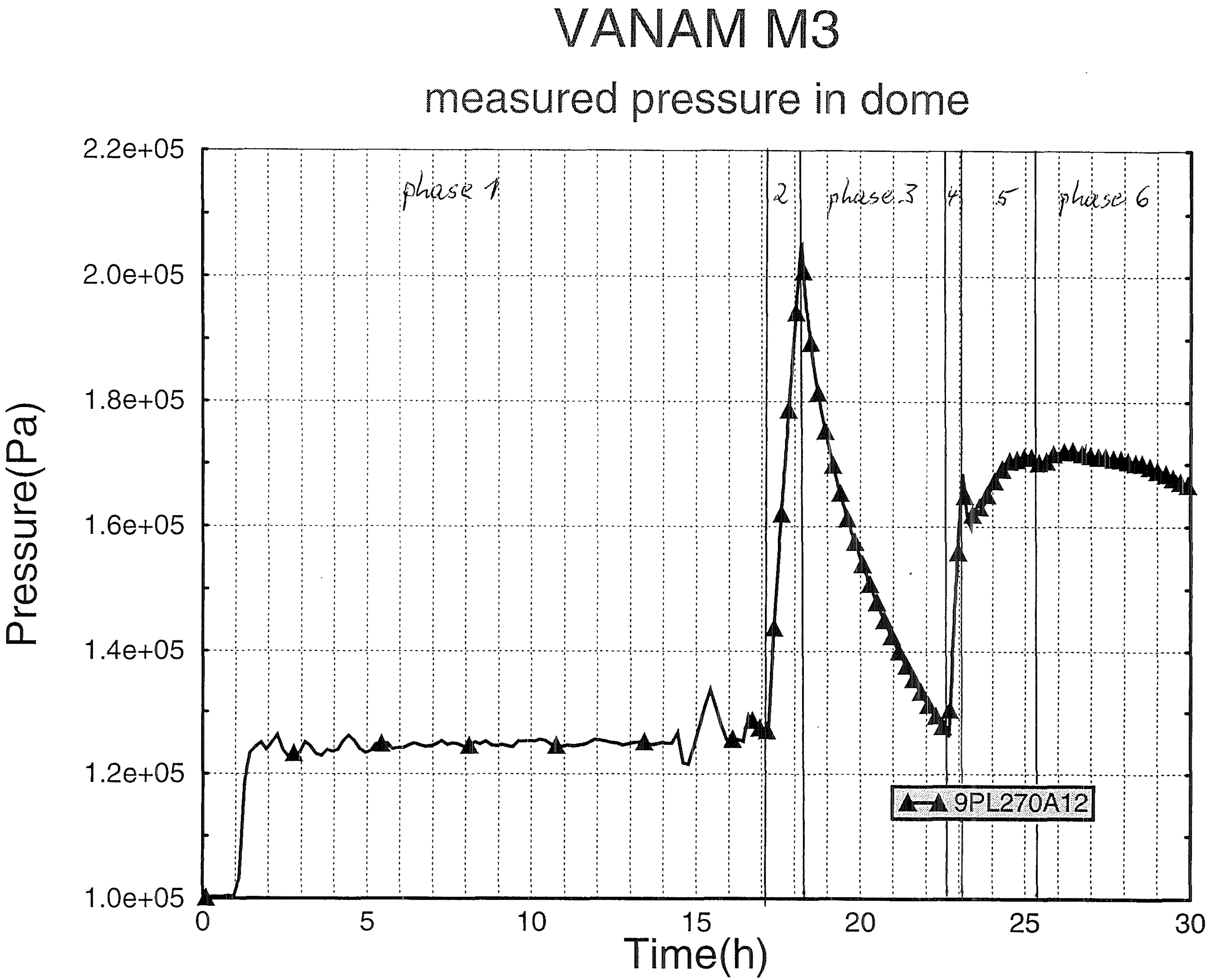
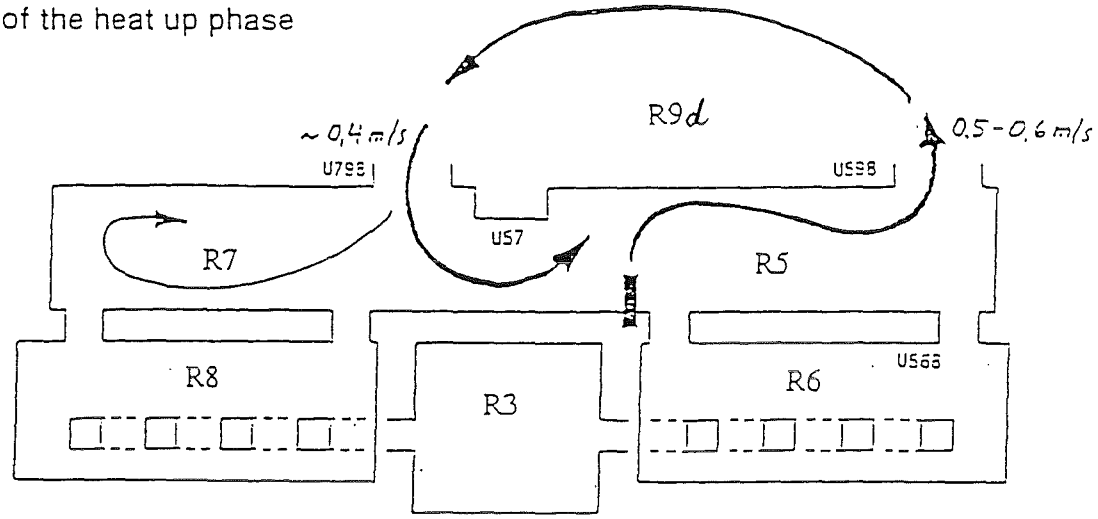

VANAM M3
measured pressure in dome
Pressure(Pa)
2.2e+05
2.0e+05
1.8e+05
1.6e+05
1.4e+05
1.2e+05
1.0e+05
0
5
10
15
20
25
30
Time(h)
phase 1
2
phase 3
4
5
phase 6
9PL270A12

Fig. 4

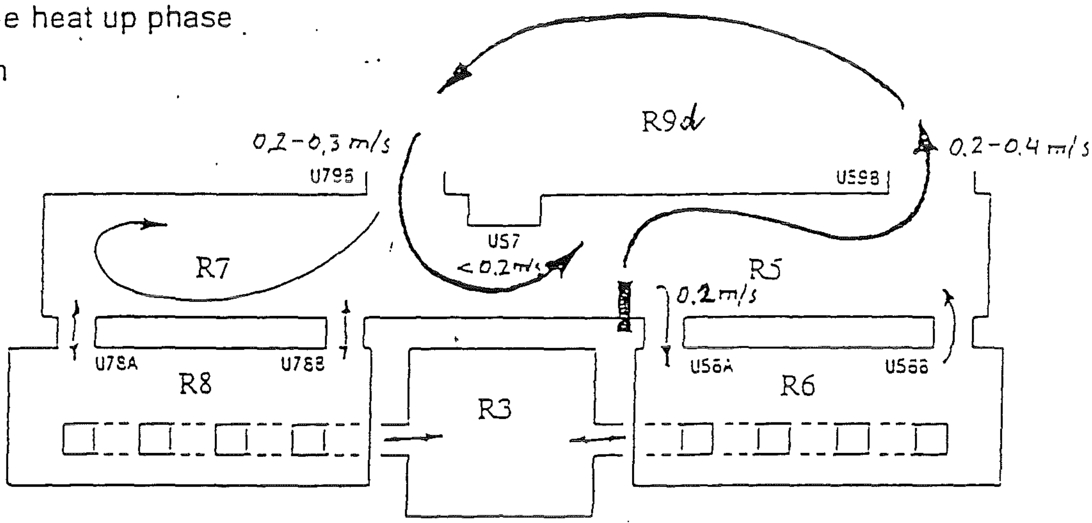
Beginning of the heat up phase

t = 1.2 - 4 h



Middle of the heat up phase

t = 5 - 10.5 h



First aerosol injection phase, pressure rise

t = 17.4 - 18.2 h

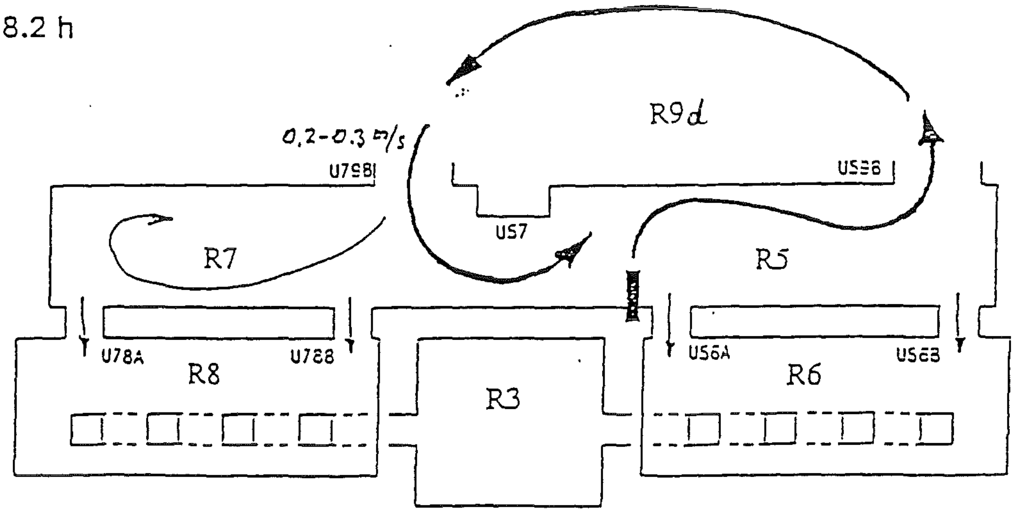
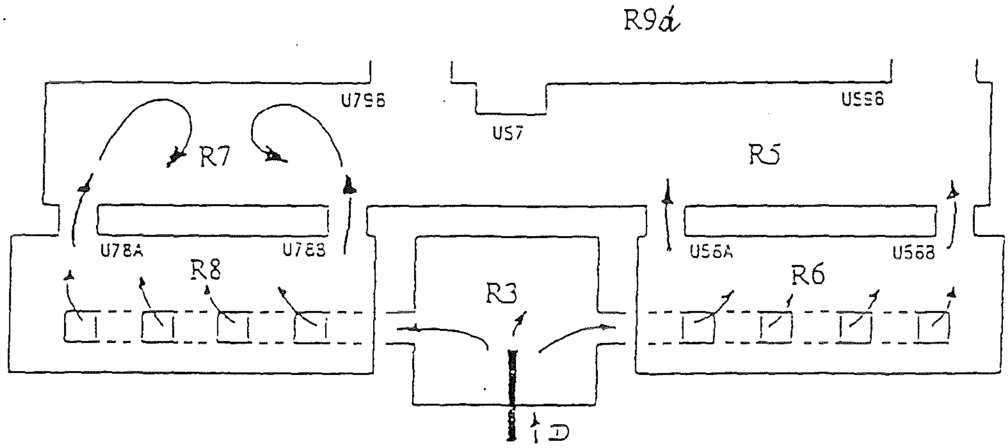


Figure 5: Atmospheric flow patterns observed in the test VANAM M3 (copied from /1/)

Beginning of mixing phase

t = 23.3 - 23.7 h



Main period of mixing phase

t = 23.7 - 25.3 h

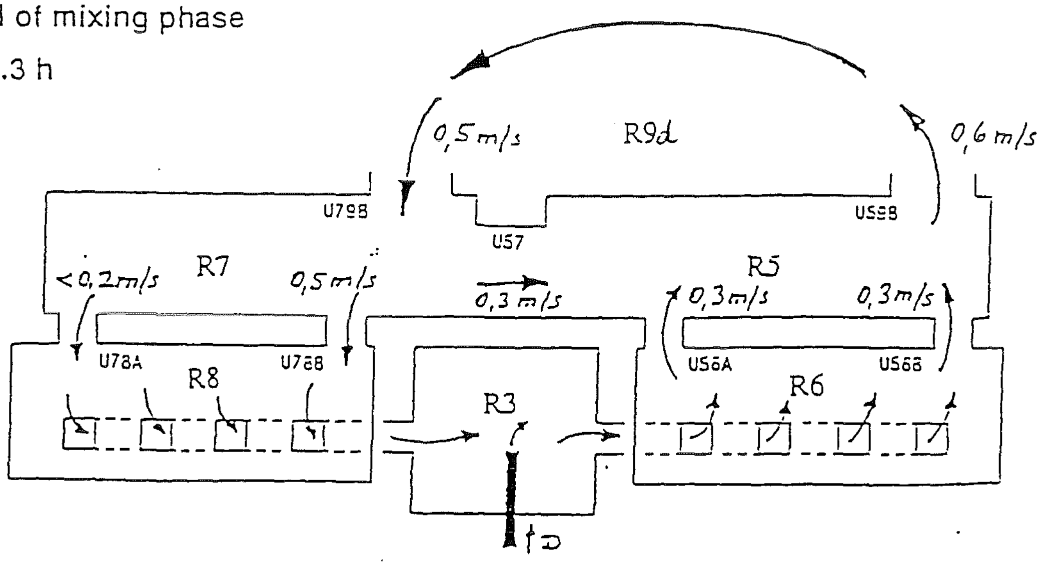
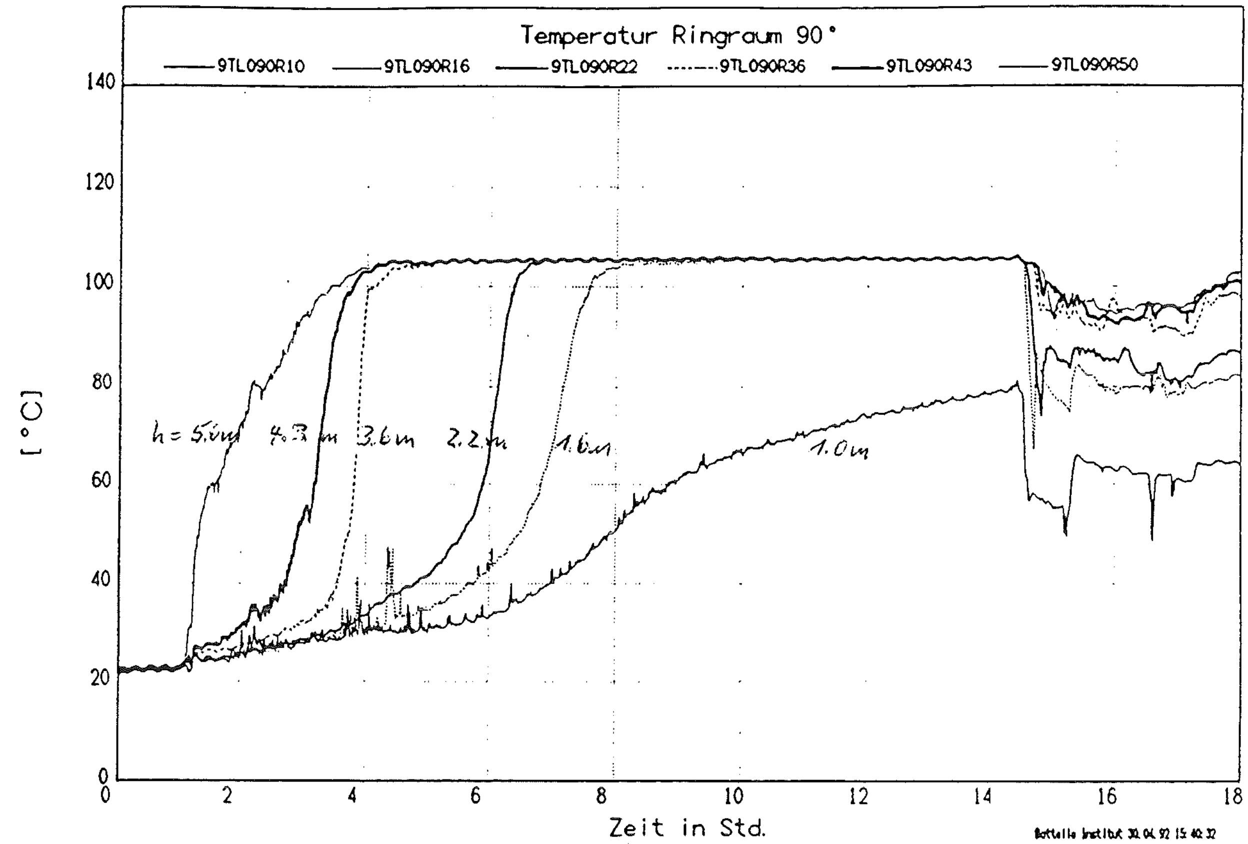


Figure 5: (continued)



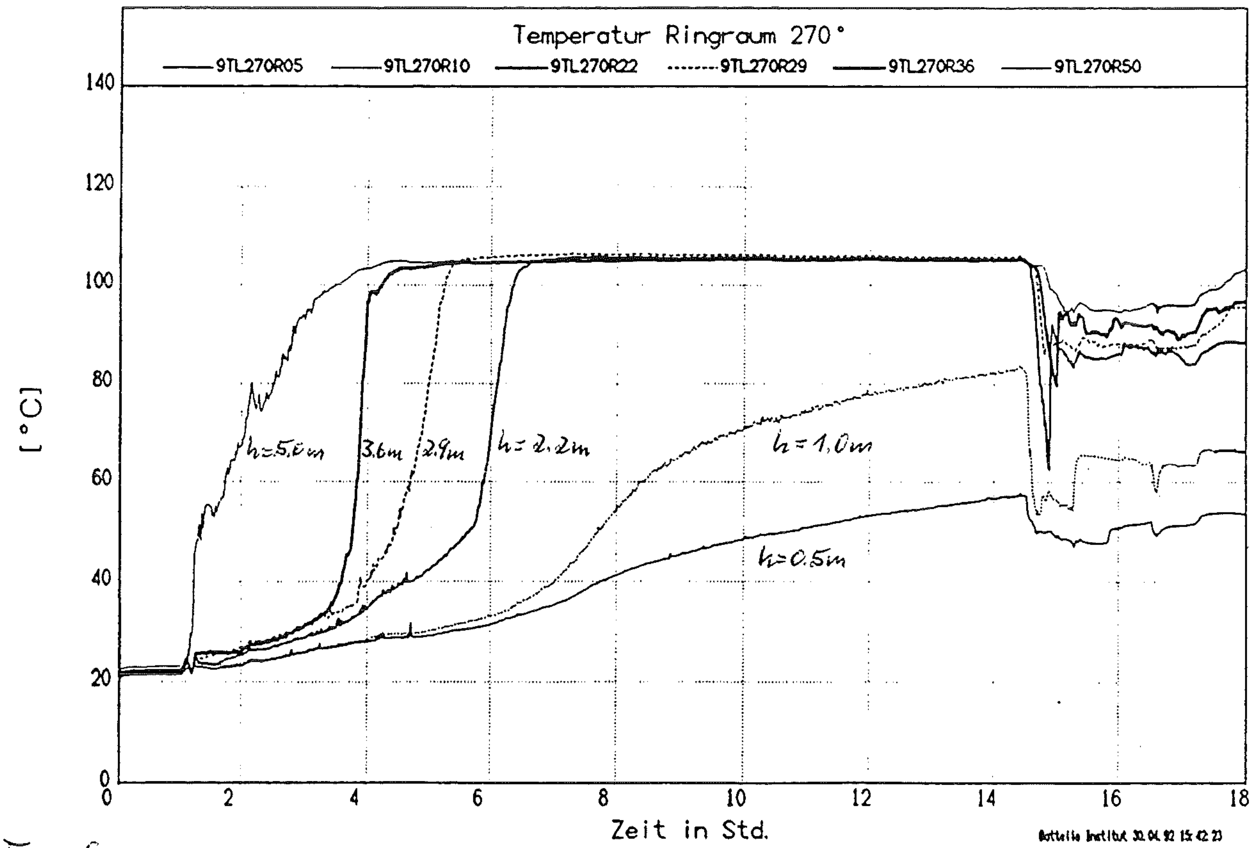
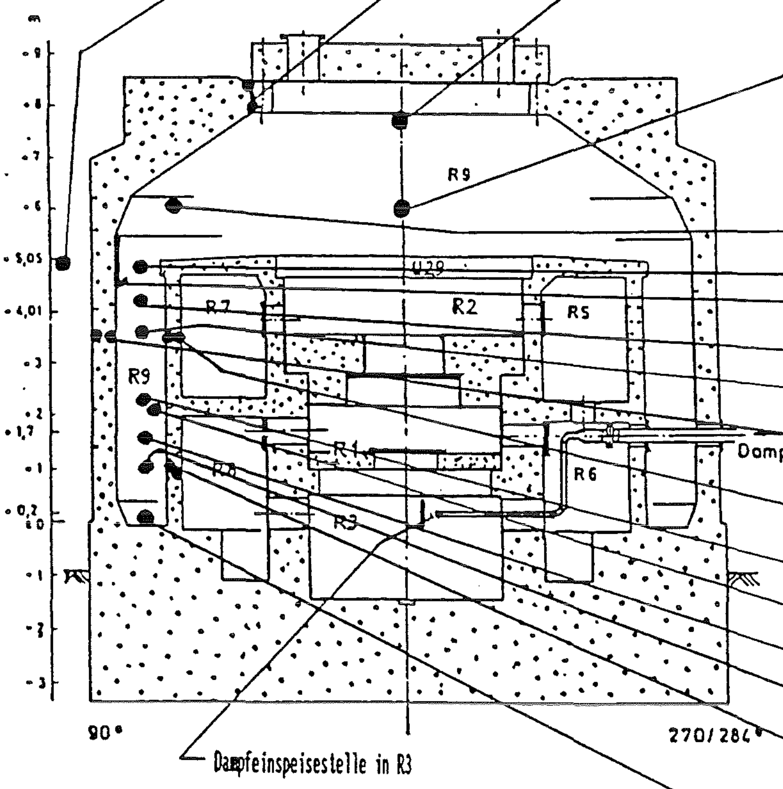


Fig: 6

VANAM-Versuch M3, Aufheizphase (t = 1,13 - 17,20 h):
Temperaturen in R9-Ringraum bei 90 und 270° in verschiedenen Höhen

Meßstellenplan R9 (0-180°)

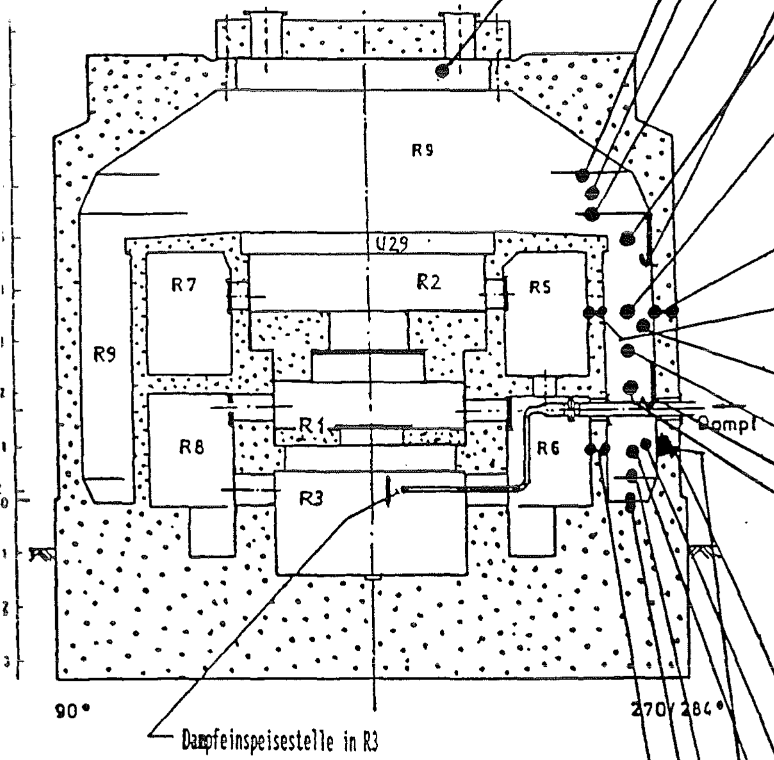


Meßsystem, direkte Meßgröße	abs. Höhe m	Bemerkung, abgeleitete Meßgröße(n)
UTL	5,0	
CTL000A91W	9,1	(1 cm tief)
9TL000A85W	8,5	(1 cm tief)
9TL000M76	7,6	
E-Photom. 4 (9UP000M76)	7,6	9EP000M76 9CP000M76
Filterst. 4	7,6	9CF000M76 9DF000M76
9TL000M60	6,0	
E-Photom. 2 (9UP000M60)	6,0	9EP000M60 9CP000M60
Filterst. 3	6,0	9CF000M60 9DF000M60
Kalorim. 1	6,0	9CK000M60
S-Photom. 1	6,0	9DP000M60
9TL090K60	6,0	
9TL090R50	5,0	
9LS090A50K	5,0	(1 m² Beton)
9TL090R43	4,3	
9TL090R36	3,6	
9TL090A36W	3,6	(1 cm tief)
CTL090A36W	3,6	(1 cm tief)
9TL090I35W	3,5	(1 cm tief)
7TL090A12W	3,5	(1 cm tief)
9TL090R22	2,2	
Kalorim. 2	2,0	9CK090M20
9TL090R16	1,6	
9TL090R10	1,0	
9TL090I10W	1,0	(1 cm tief)
8TL090A18W	0,8	(1 cm tief)
9TL100R02S	0,2	
9TL100R01S	0,1	
9TL100R00S	0,0	
9LK	0,0	

Fig. 7 : Thermocouple locations

VANAM-Versuche M2*, M3, M4: **Meßstellenplan für R9 (0-180°)**

Meßstellenplan R9 (180°-360°)



Meßsystem, direkte Meßgröße	abs. Höhe m	Bemerkung, abgeleitete Meßgröße(n)
9HK194M83	8,3	
9TK194M83	8,3	
9TL270K60	6,0	
9HK270A57	5,7	
9TK270A57	5,7	
9TL271K55	5,5	
9TL273K55	5,5	
WÜ-Block 1	5,5	9TL270W550 9QW270W55 9ZW270W55
9LS205A50K	5,0	(1 m² Beton)
9TL270R50	5,0	
9TL270R36	3,6	
E-Photom. 3 (9UP270M36)	3,6	9EP270M36 9CP270M36
Filterst. 2	3,6	9CF270M36 9DF270M36
9TL270A36W	3,6	(1 cm tief)
CTL270A36W	3,6	(1 cm tief)
9TL270I35W	3,5	(1 cm tief)
5TL270A12W	3,5	(1 cm tief)
9HK187A35	3,5	
9TK187A35	3,5	
9TL270R29	2,9	
9LS205A24K	2,4	(1 m² Beton)
9TL270R22	2,2	
9TL264R22	2,2	
9TL266R22	2,2	
WÜ-Block 2	2,2	9TL265W220 9QW265W22 9ZW265W22
9PL270A12	1,2	
9PL271A12	1,2	
9HK270A11	1,1	
9TK279A11	1,1	
9TL270R10	1,0	
E-Photom. 7 (9UP270M10)	1,0	9EP270M10 9CP270M10
Filterst. 1	1,0	9CF270M10 9DF270M10
9TL270A10W	1,0	(1 cm tief)
CTL270A10W	1,0	(1 cm tief)
9TL270I10W	1,0	(1 cm tief)
6TL270A20W	1,0	(1 cm tief)
9TL270R05	0,5	
9TL270R00S	0,0	
9TL270M-1W	-0,1	(10 cm tief)

Fig. 7 (continued): Thermocouple locations

VANAM-Versuche M2*, M3, M4: **Meßstellenplan** für R9 (180-360°)

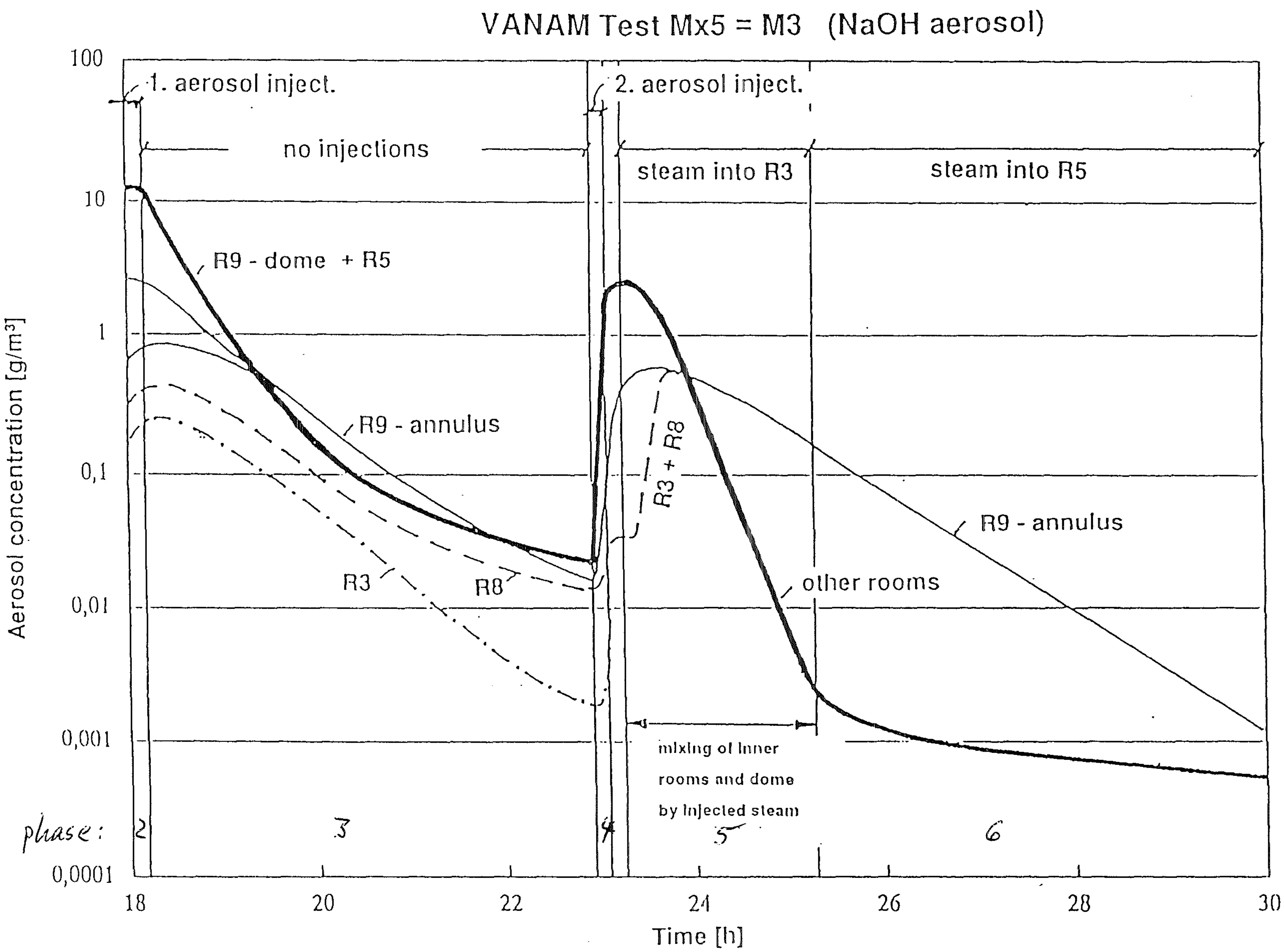


Figure 8: Measured histories of NaOH aerosol concentrations in different rooms

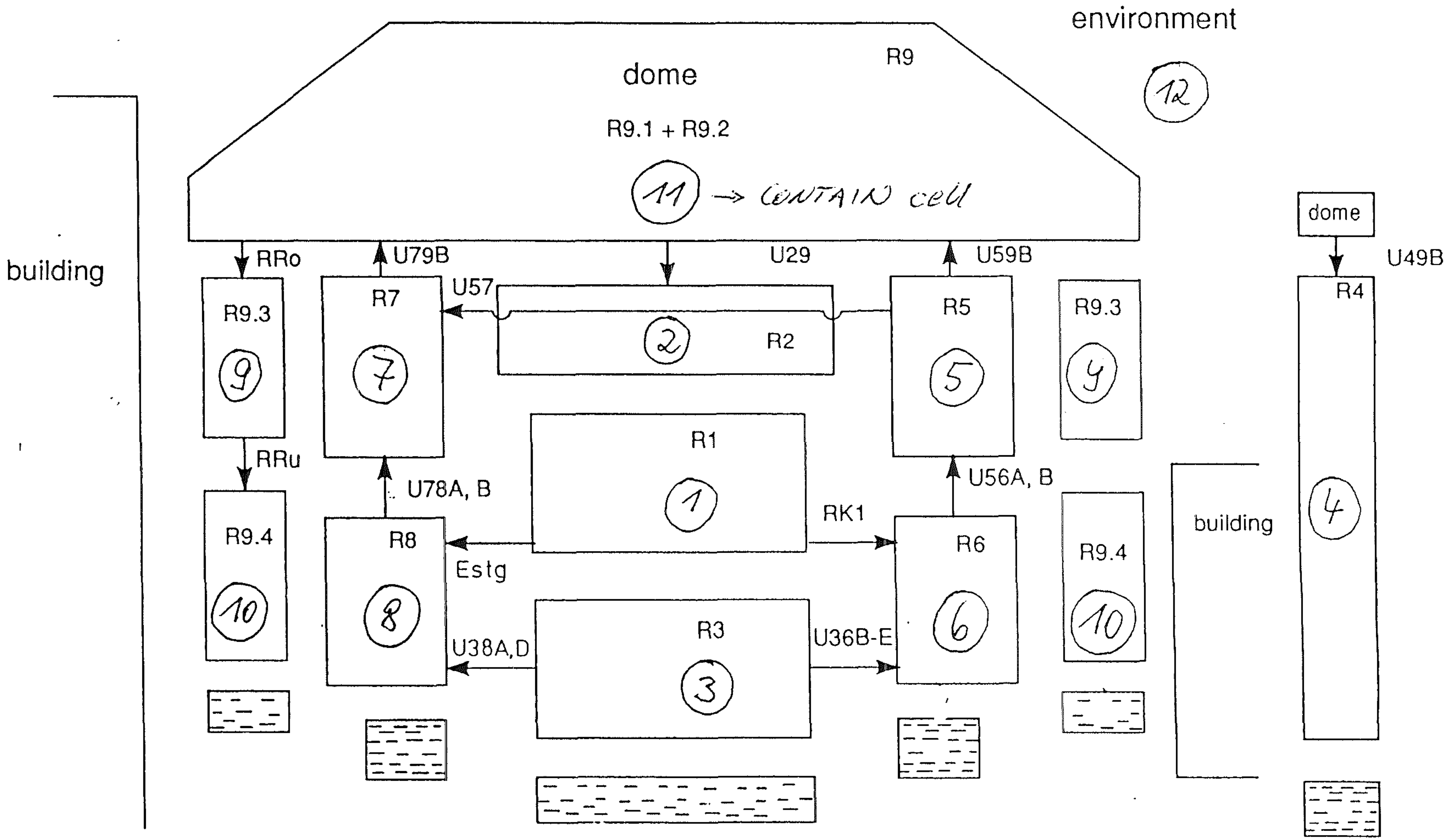


Figure 9: Proposed nodalisation for the ISP37 on VANAM M3

Atmospheric flow paths

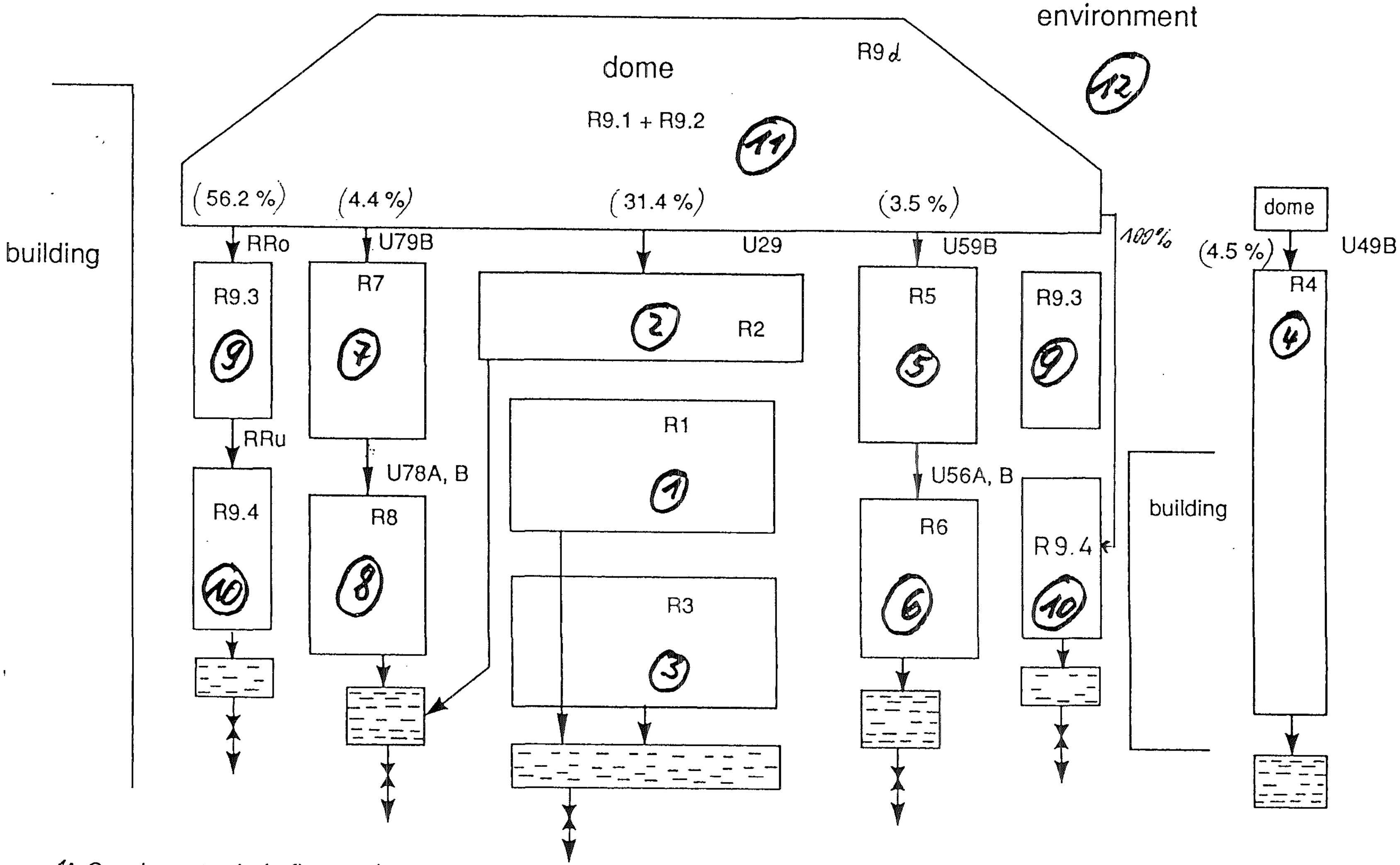


Figure 10: Condensate drain flow paths

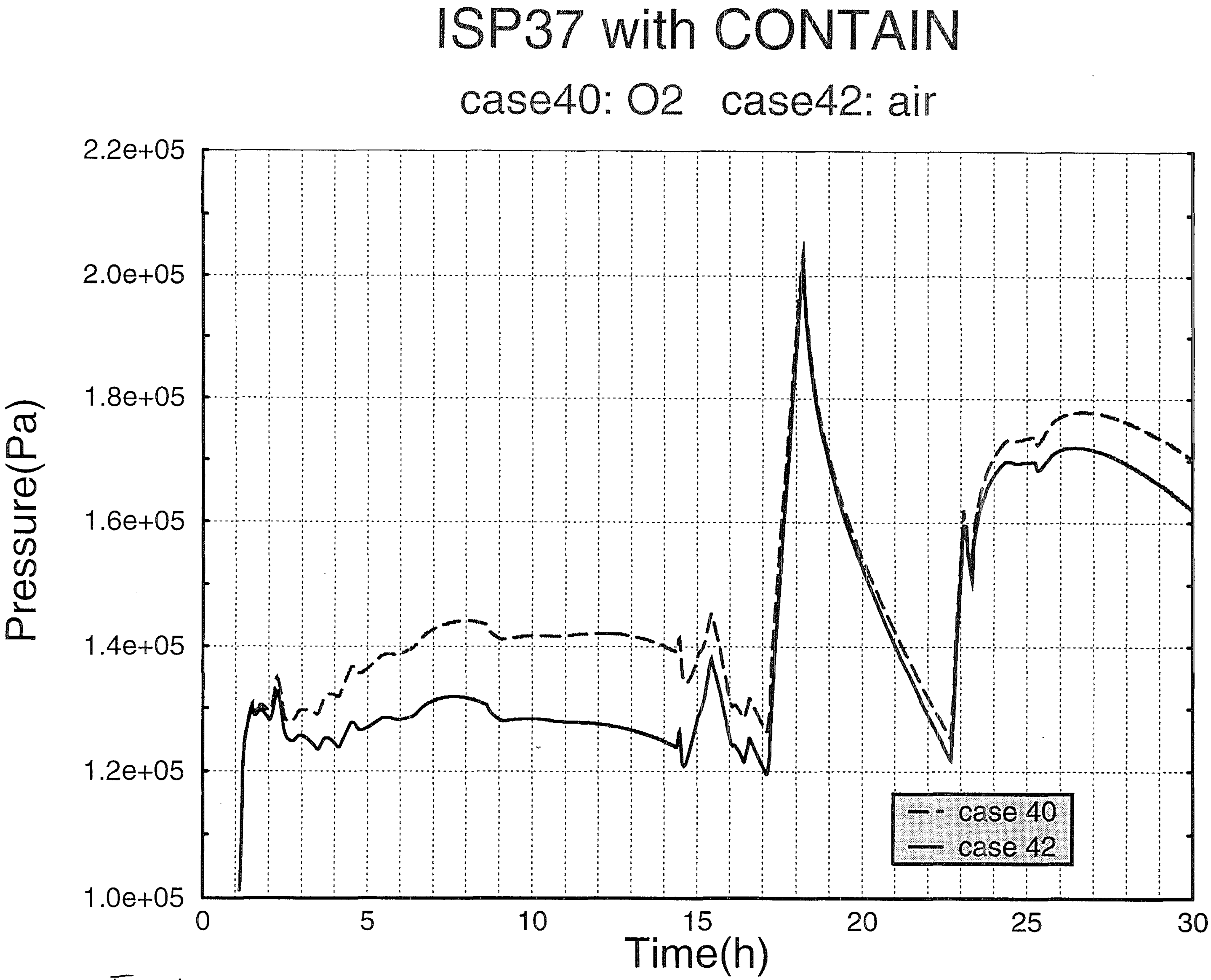

ISP37 with CONTAIN
case40: O2   case42: air
2.2e+05
2.0e+05
1.8e+05
1.6e+05
1.4e+05
1.2e+05
1.0e+05
Pressure(Pa)
0
5
10
15
20
25
30
Time(h)
case 40
case 42

Fig. 11

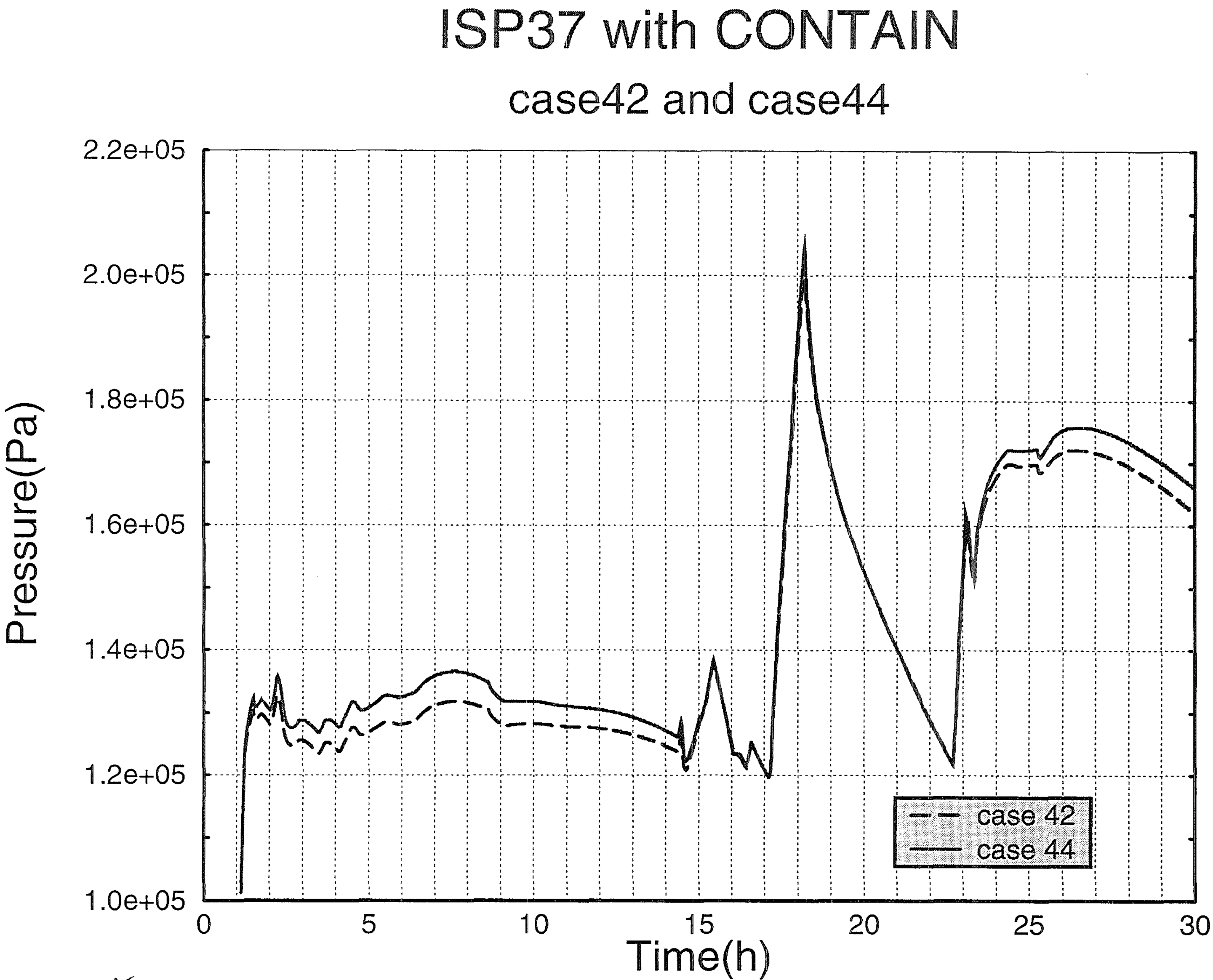

ISP37 with CONTAIN
case42 and case44
Pressure(Pa)
2.2e+05
2.0e+05
1.8e+05
1.6e+05
1.4e+05
1.2e+05
1.0e+05
0
5
10
15
20
25
30
Time(h)
case 42
case 44

Fig. 12

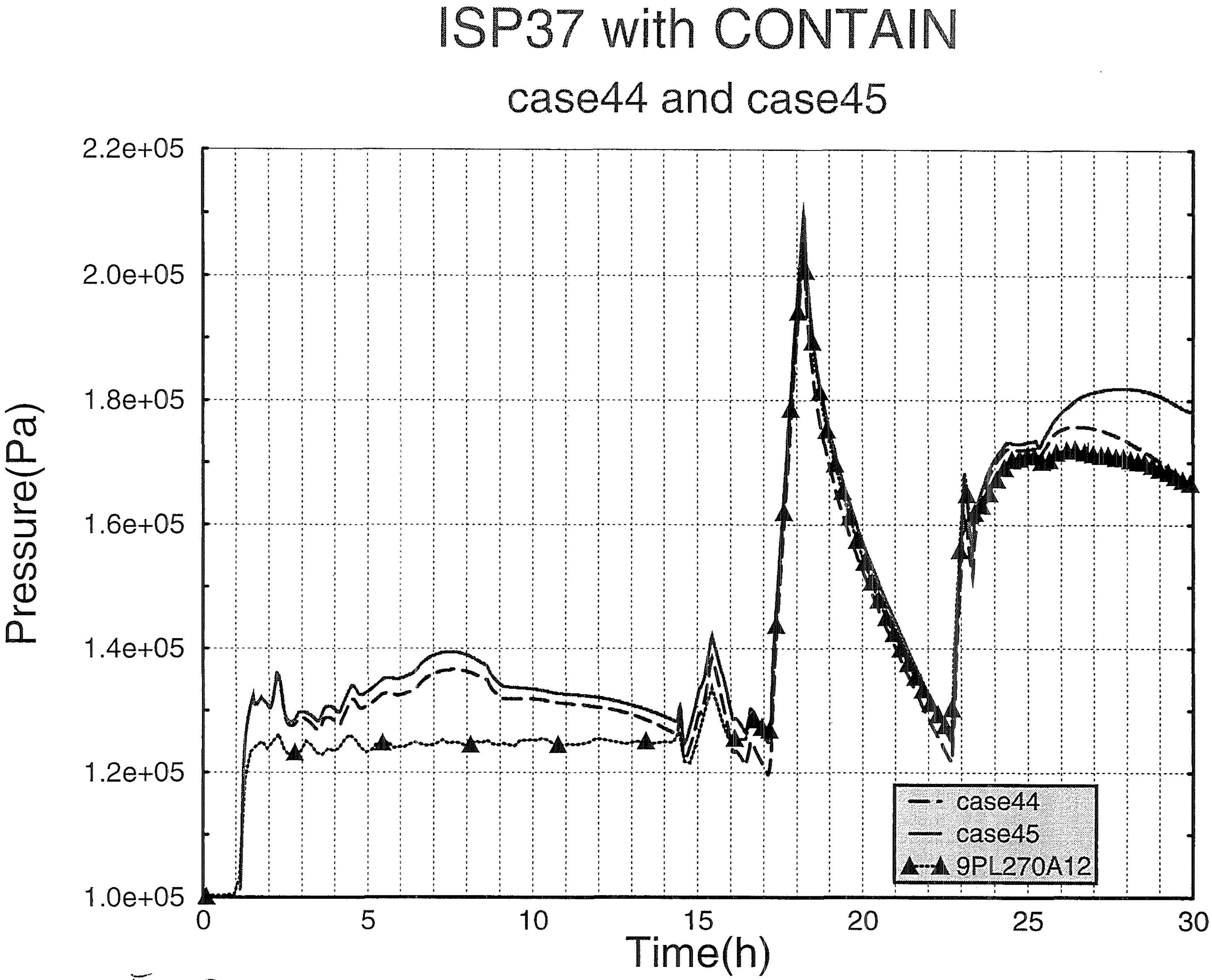
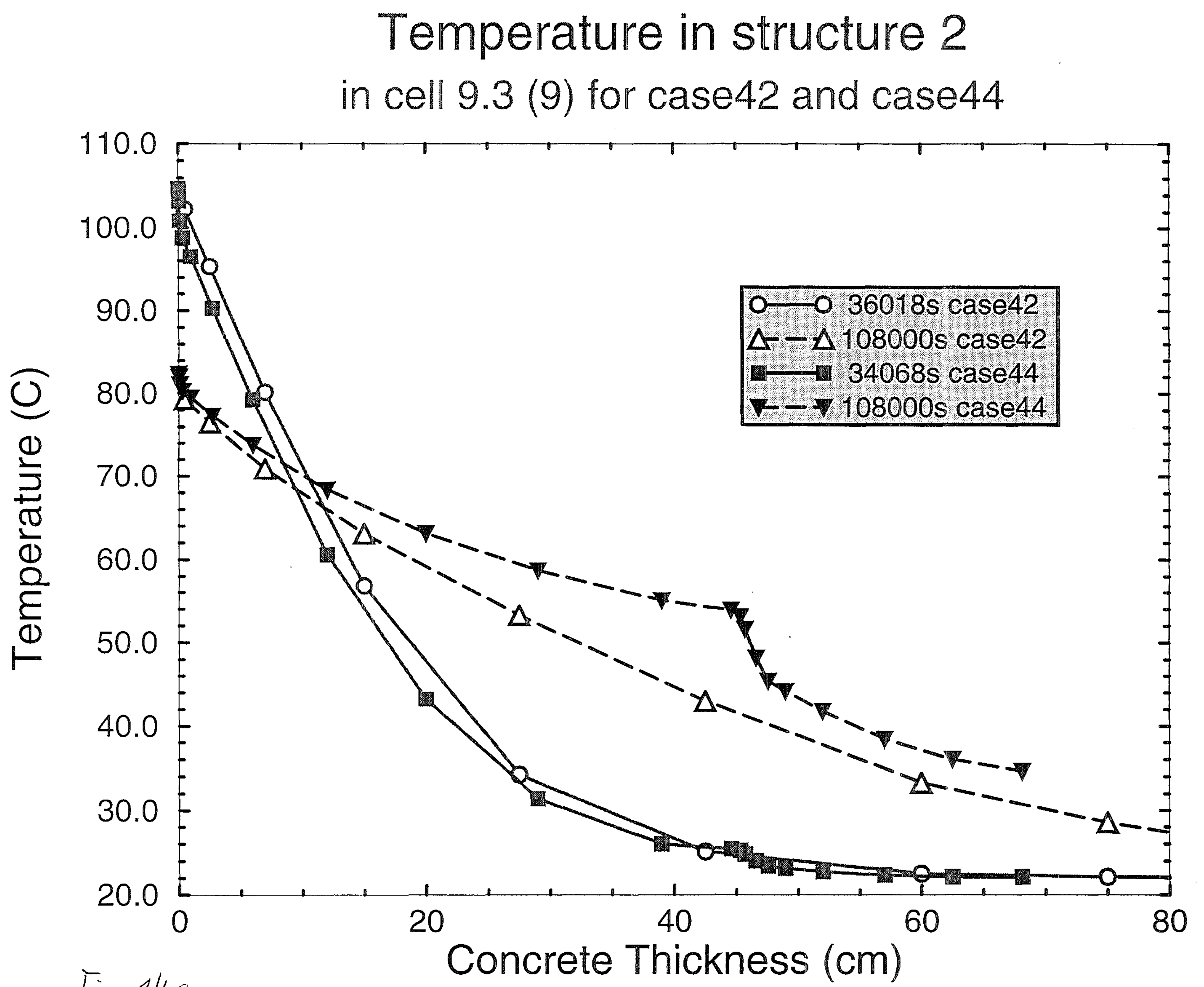
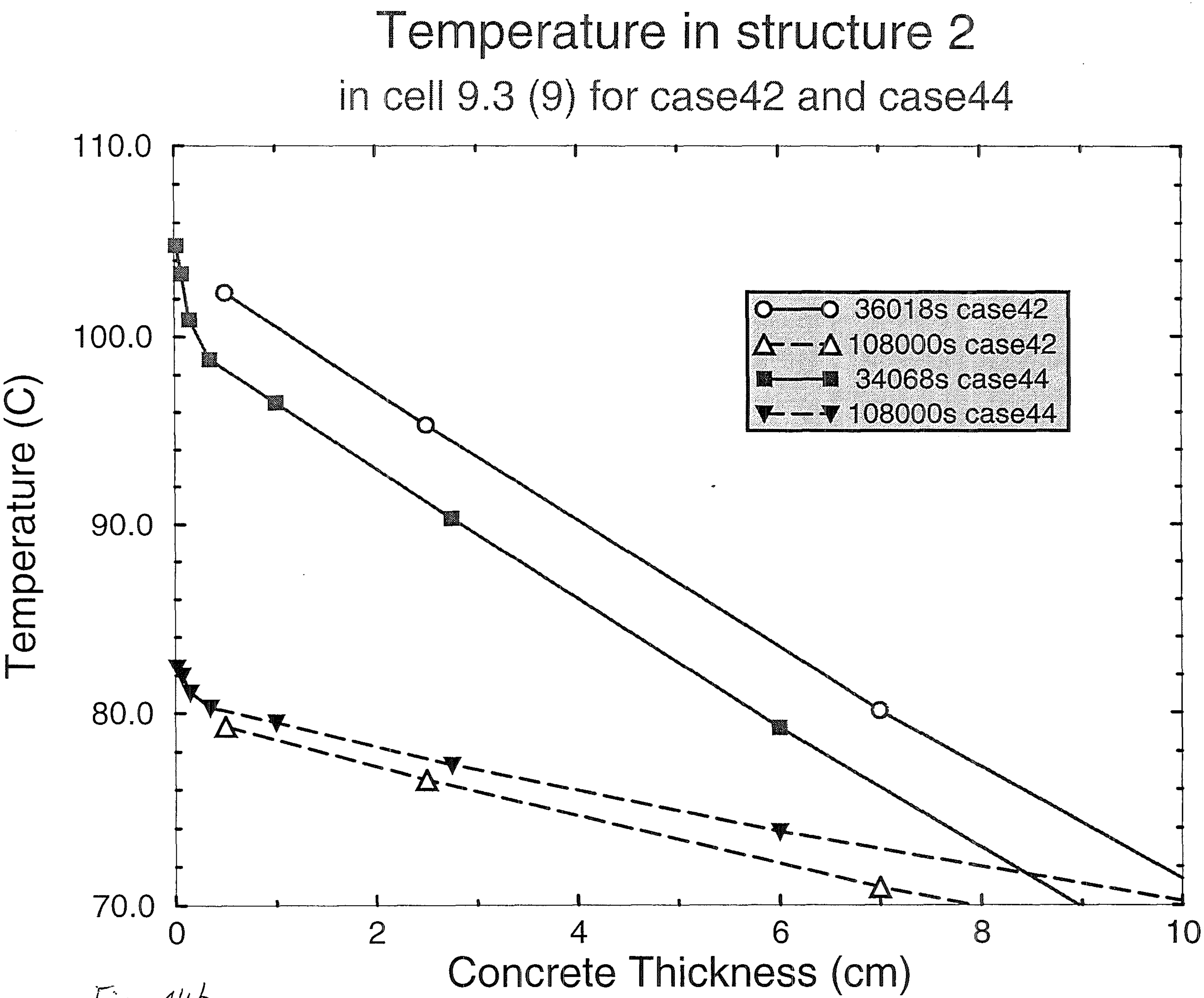

ISP37 with CONTAIN
case44 and case45
Pressure(Pa)
2.2e+05
2.0e+05
1.8e+05
1.6e+05
1.4e+05
1.2e+05
1.0e+05
0
5
10
15
20
25
30
Time(h)
case44
case45
9PL270A12

Fig. 13



Temperature in structure 2
in cell 9.3 (9) for case42 and case44
Temperature (C)
Concrete Thickness (cm)
36018s case42
108000s case42
34068s case44
108000s case44
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
0
20
40
60
80

Fig. 14a



Temperature in structure 2
in cell 9.3 (9) for case42 and case44
110.0
100.0
90.0
80.0
70.0
Temperature (C)
0
2
4
6
8
10
Concrete Thickness (cm)
36018s case42
108000s case42
34068s case44
108000s case44

Fig. 14b

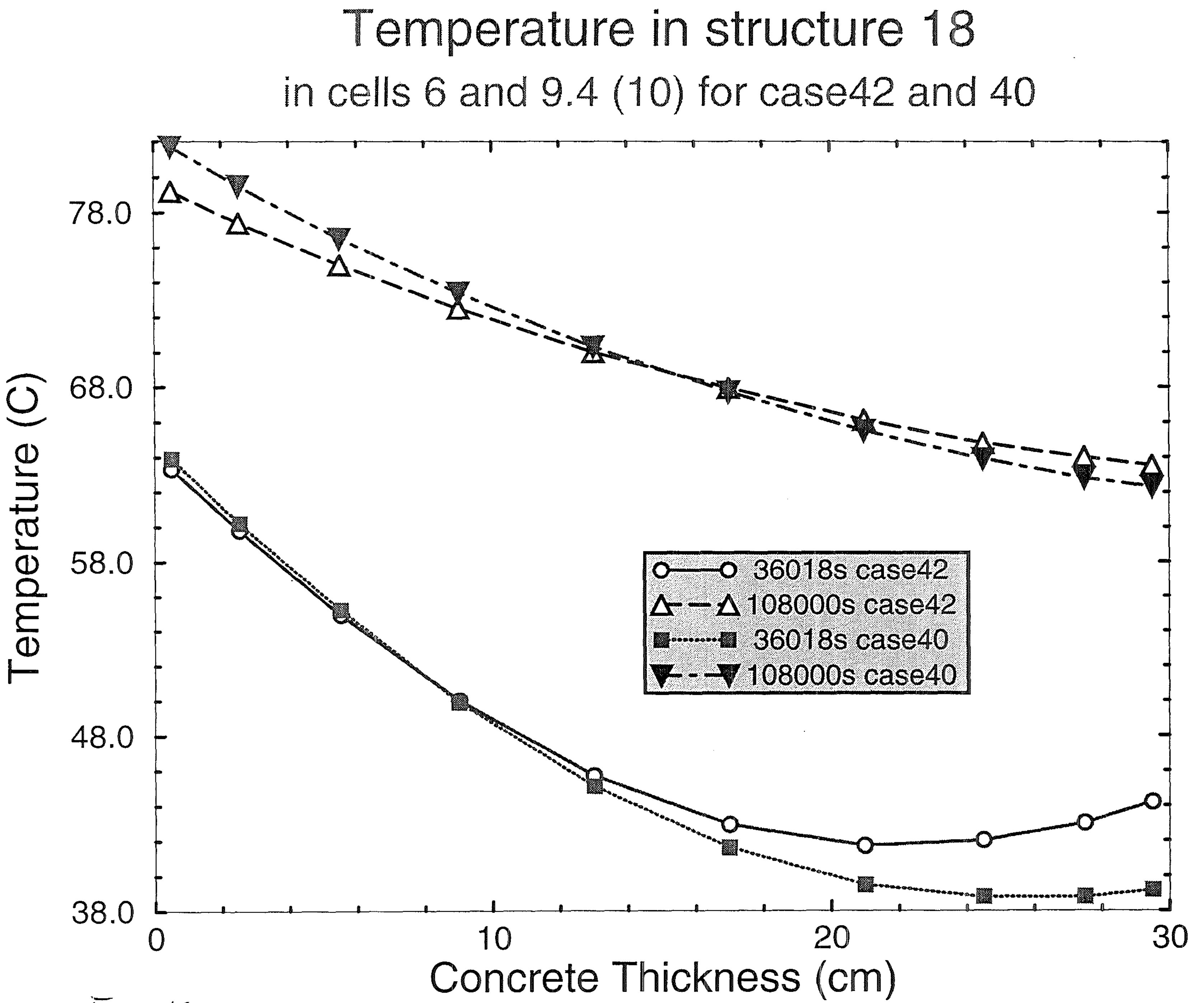
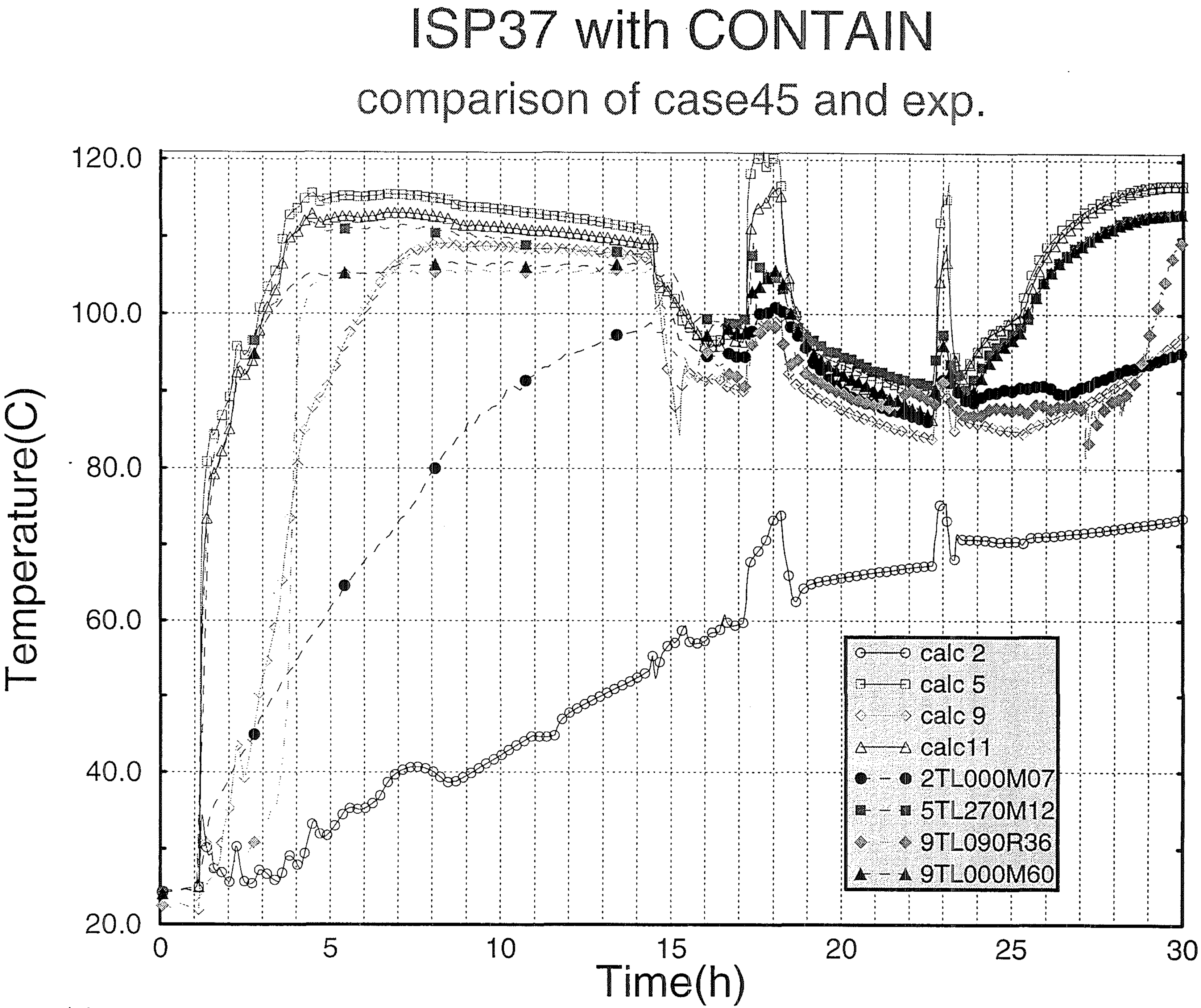

Temperature in structure 18
in cells 6 and 9.4 (10) for case42 and 40
Temperature (C)
78.0
68.0
58.0
48.0
38.0
0
10
20
30
Concrete Thickness (cm)
36018s case42
108000s case42
36018s case40
108000s case40

Fig. 15


ISP37 with CONTAIN
comparison of case45 and exp.
Temperature(C)
120.0
100.0
80.0
60.0
40.0
20.0
0
5
10
15
20
25
30
Time(h)
calc 2
calc 5
calc 9
calc11
2TL000M07
5TL270M12
9TL090R36
9TL000M60
Fig. 16

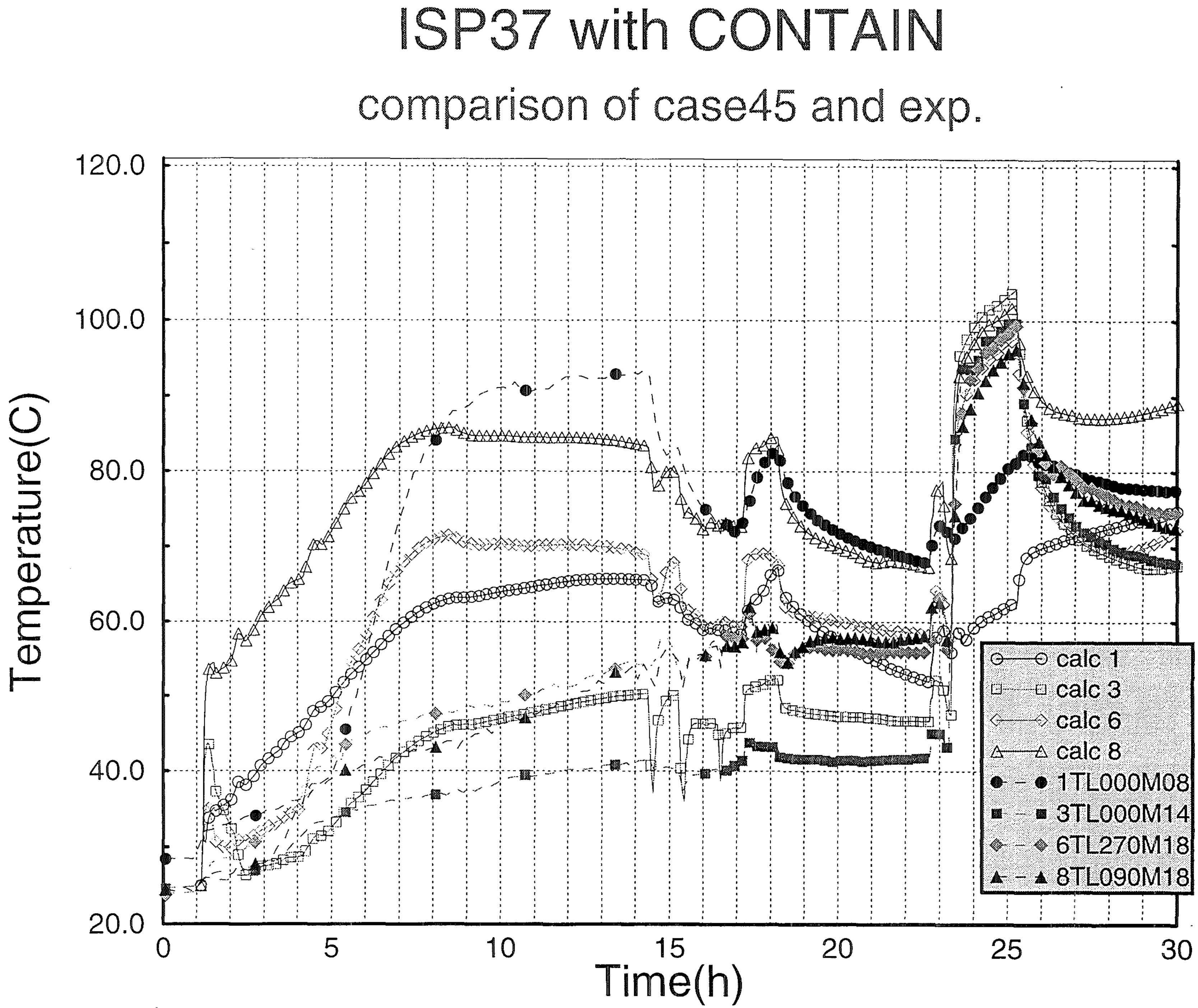

ISP37 with CONTAIN
comparison of case45 and exp.
Temperature(C)
Time(h)
120.0
100.0
80.0
60.0
40.0
20.0
0
5
10
15
20
25
30
calc 1
calc 3
calc 6
calc 8
1TL000M08
3TL000M14
6TL270M18
8TL090M18

Fig. 17

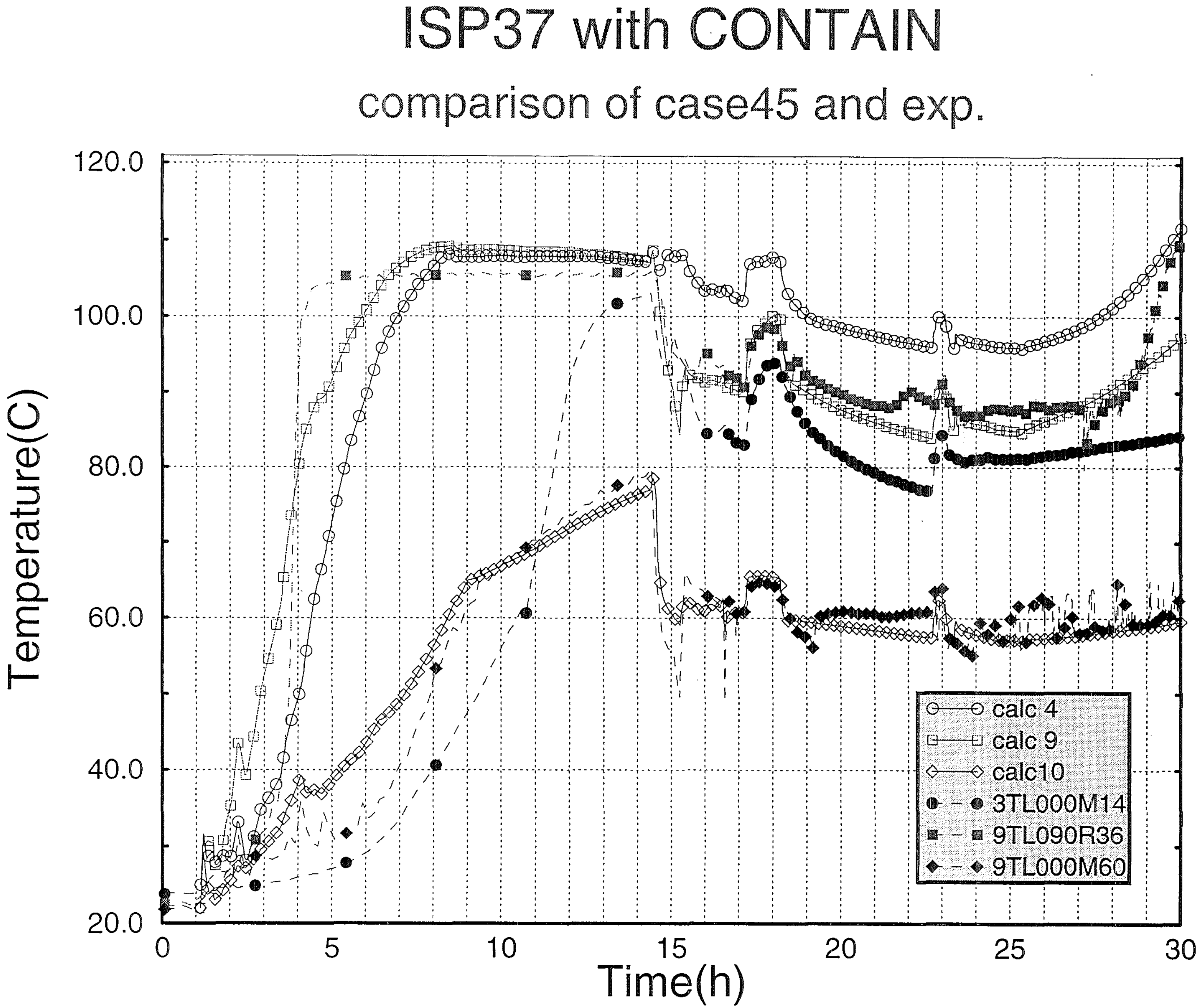

ISP37 with CONTAIN
comparison of case45 and exp.
120.0
100.0
80.0
60.0
40.0
20.0
Temperature(C)
0
5
10
15
20
25
30
Time(h)
calc 4
calc 9
calc10
3TL000M14
9TL090R36
9TL000M60

Fig. 18

— 149 —

ISP37 with CONTAIN

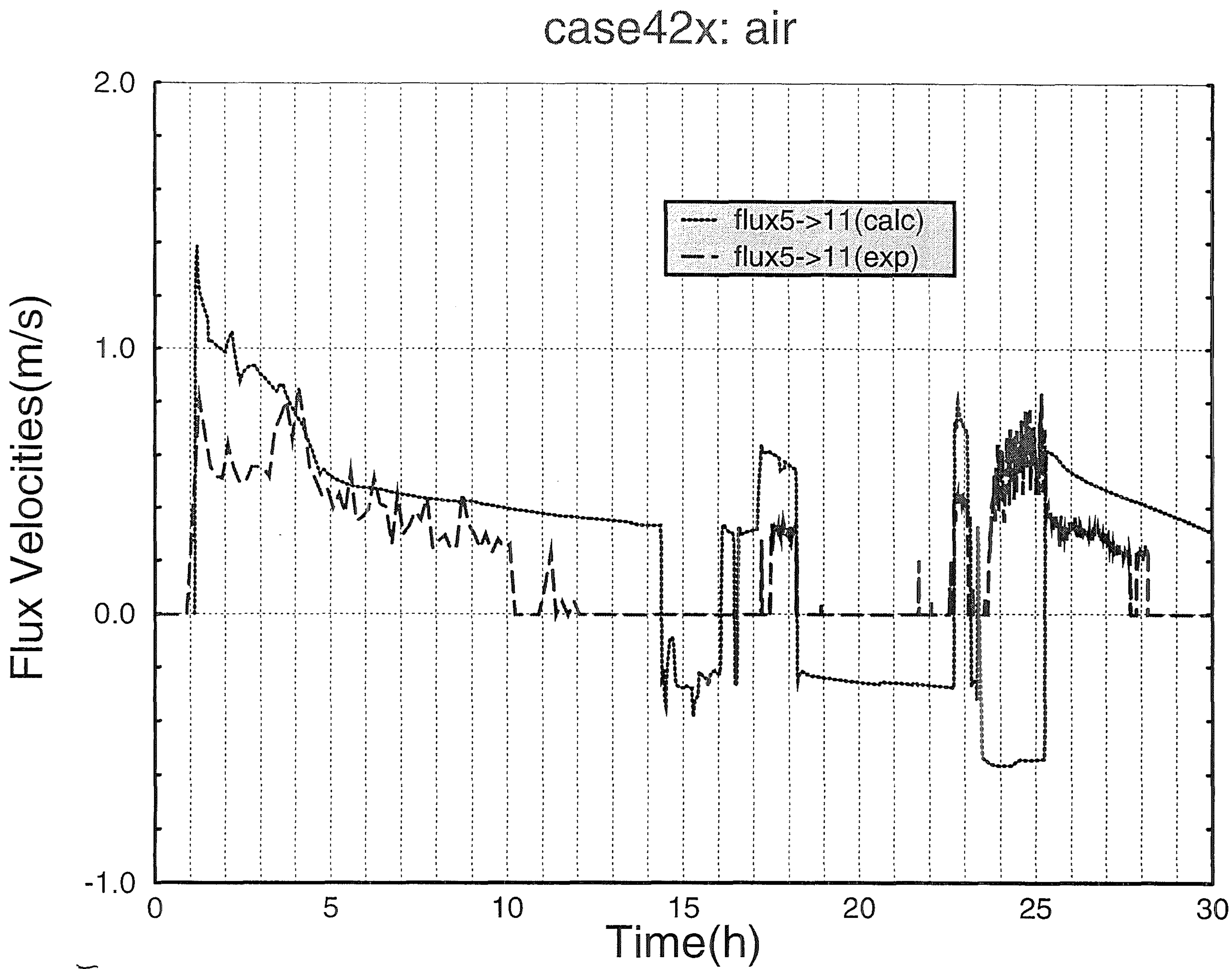


Fig. 19

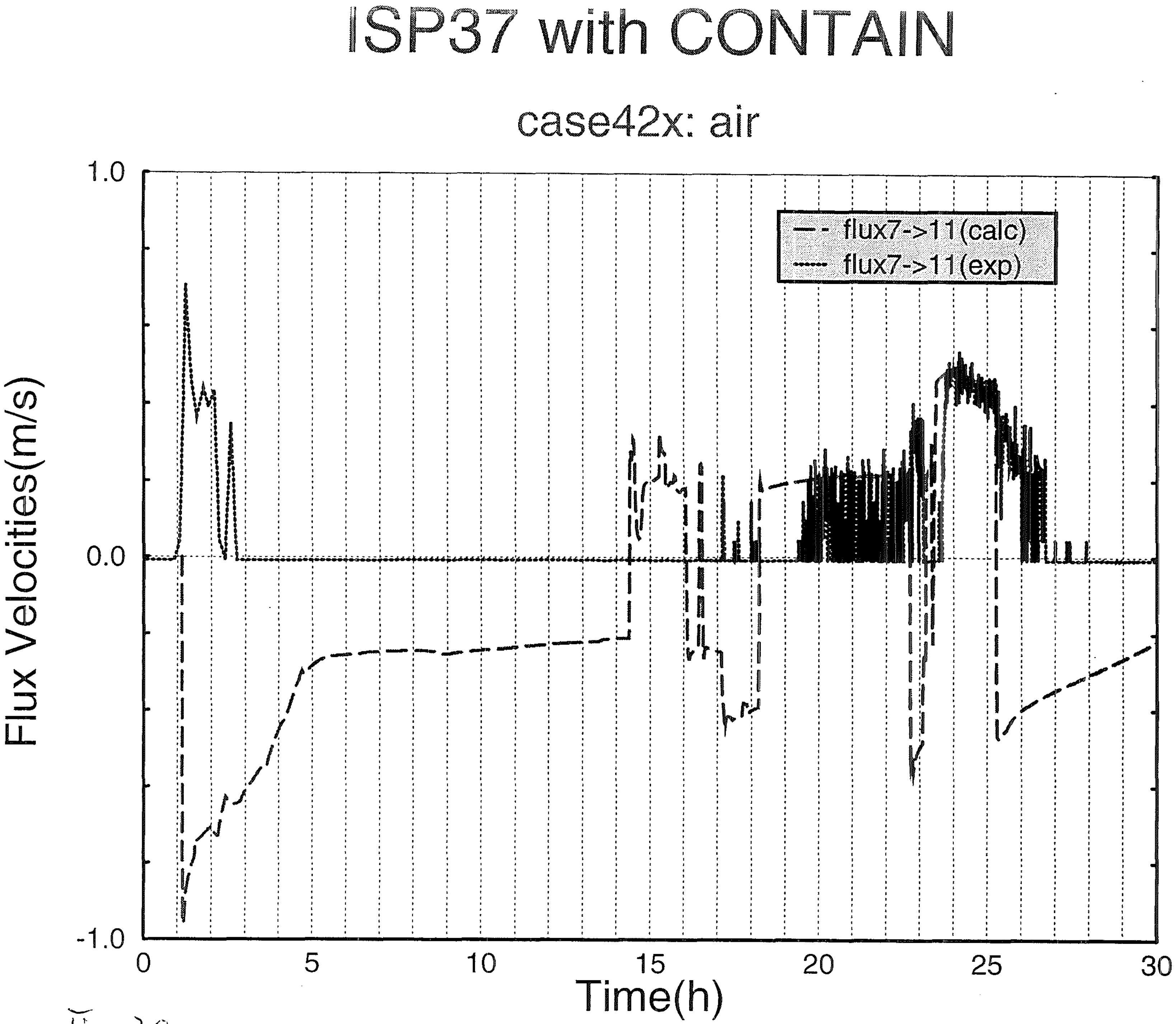

ISP37 with CONTAIN
case42x: air
flux7->11(calc)
flux7->11(exp)
Flux Velocities(m/s)
1.0
0.0
-1.0
0
5
10
15
20
25
30
Time(h)

Fig. 20

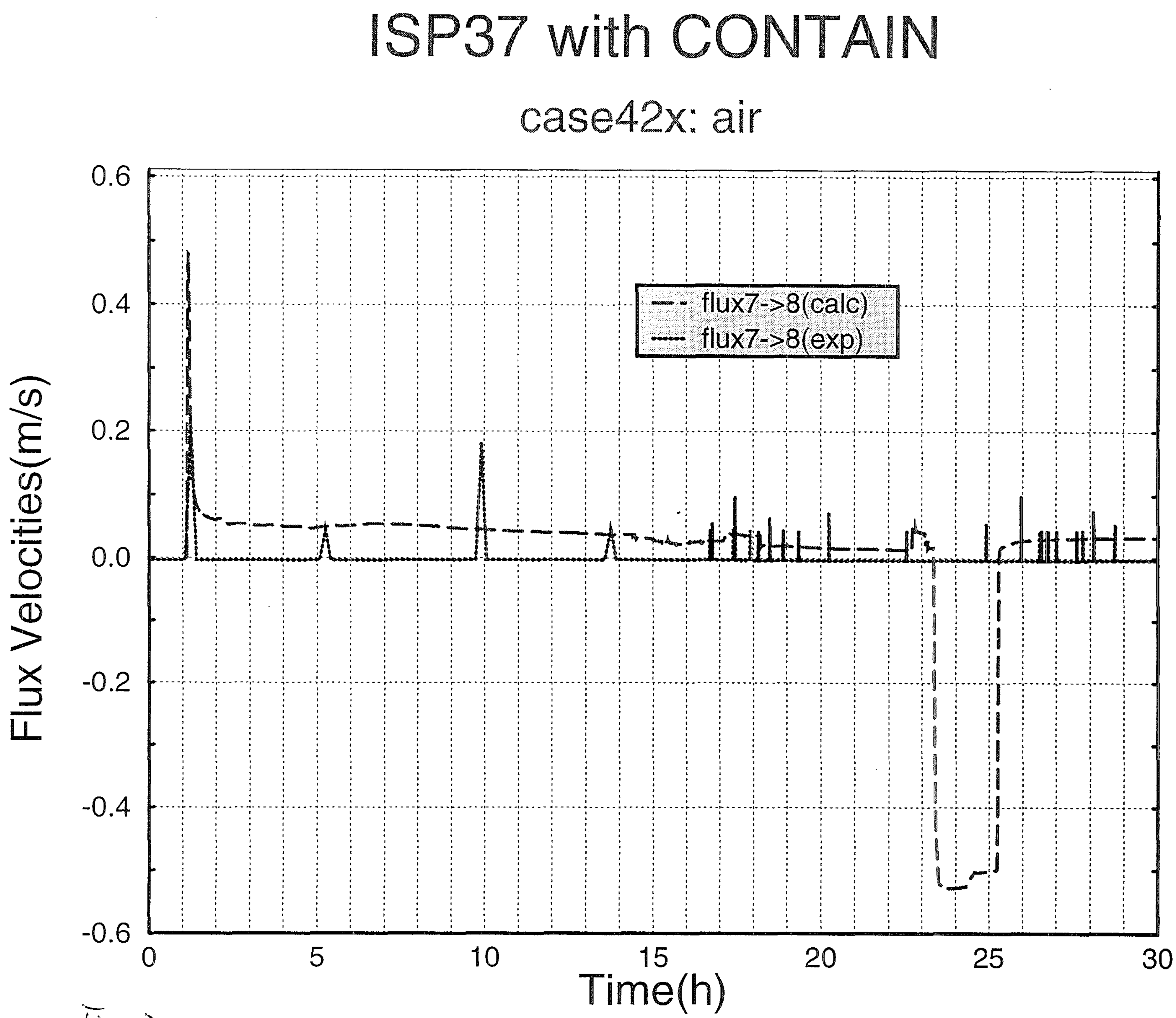

ISP37 with CONTAIN
case42x: air
flux7->8(calc)
flux7->8(exp)
Flux Velocities(m/s)
Time(h)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
5
10
15
20
25
30

Fig. 21

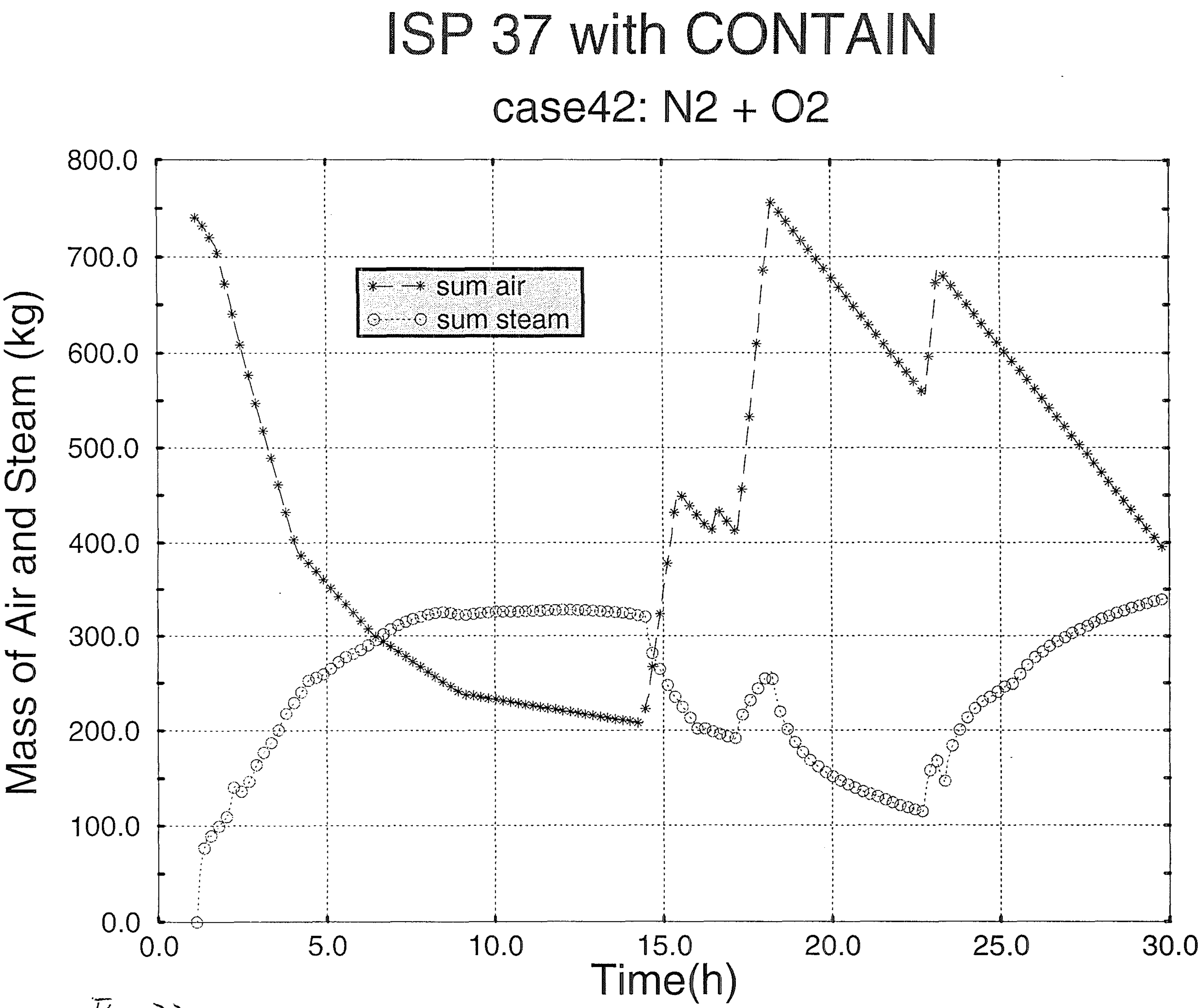

ISP 37 with CONTAIN
case42: N2 + O2
Mass of Air and Steam (kg)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Time(h)
sum air
sum steam

Fig. 22

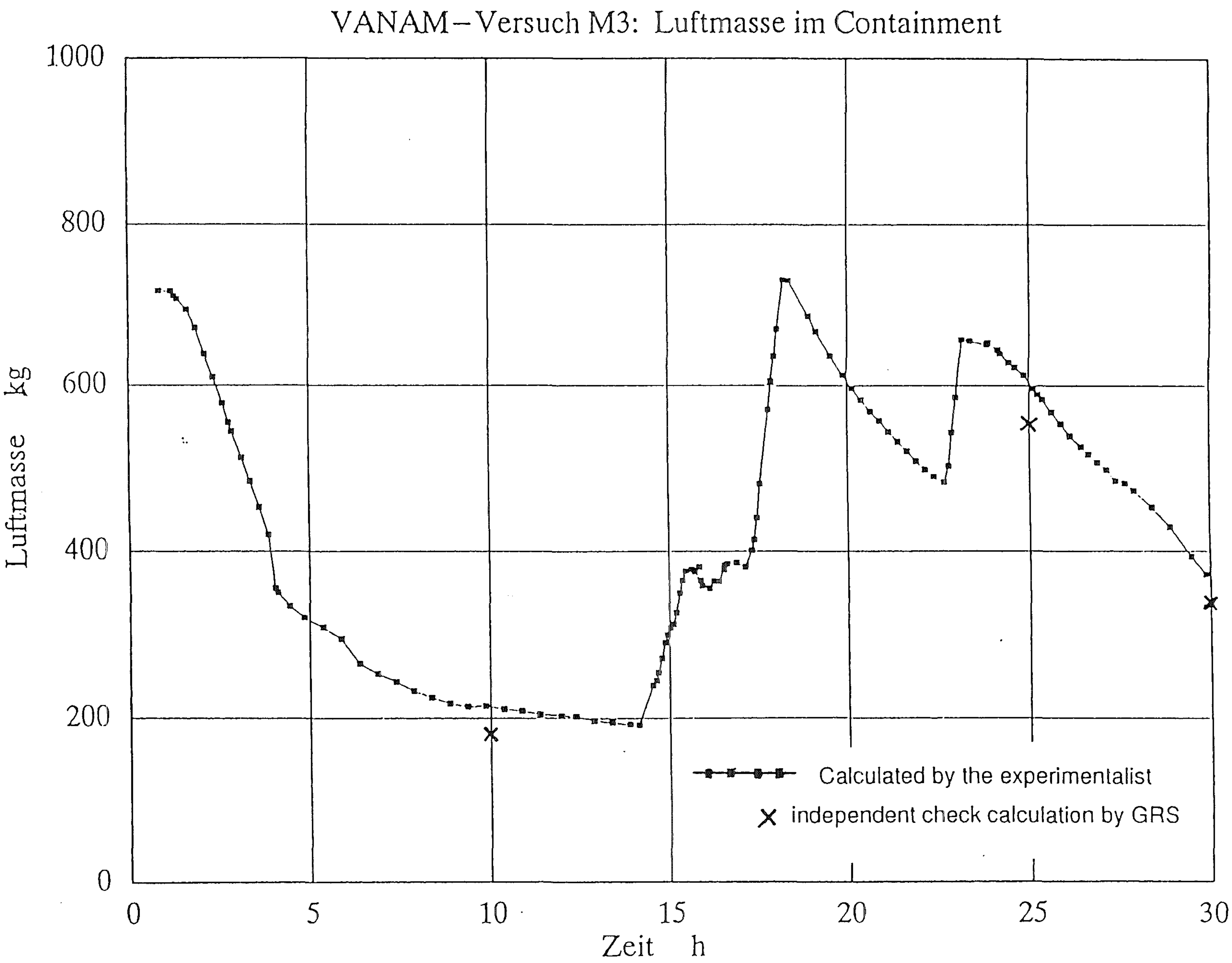


Figure 23: Air content of the model containment in the test VANAM M3

ISP37 with CONTAIN

comparison of case 45 and exp.

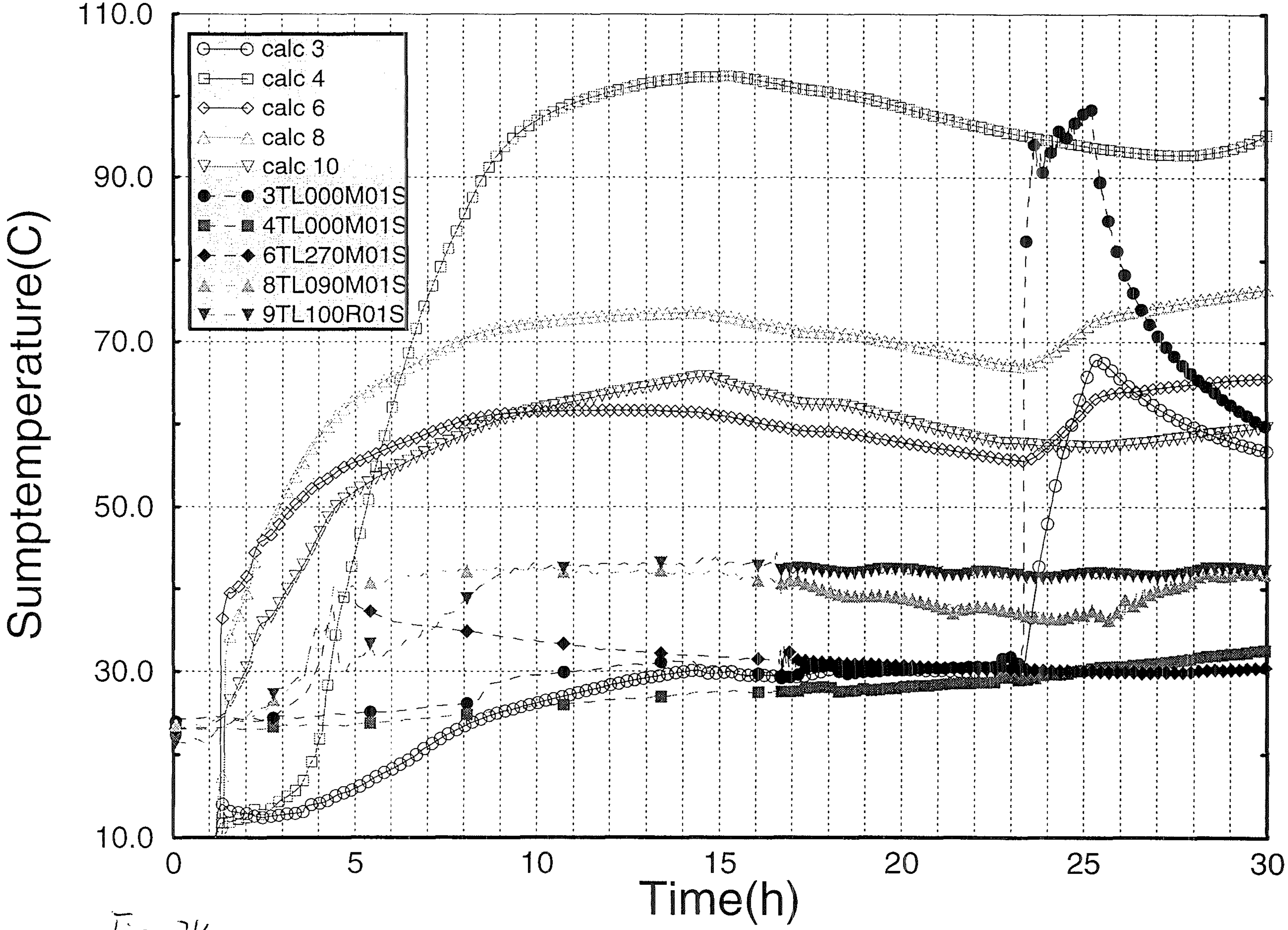


Fig. 24

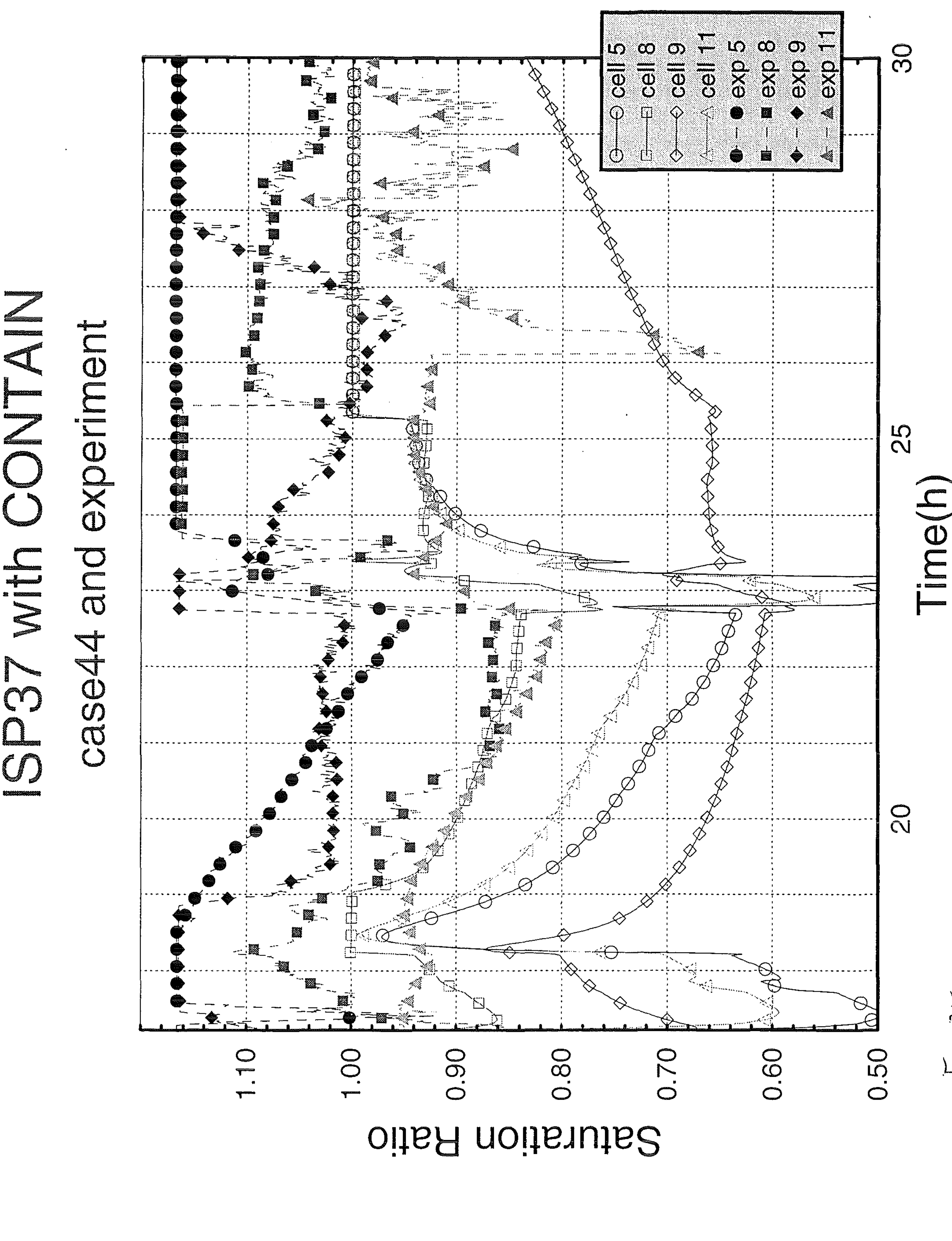

ISP37 with CONTAIN
case44 and experiment
Saturation Ratio
1.10
1.00
0.90
0.80
0.70
0.60
0.50
20
25
30
Time(h)
cell 5
cell 8
cell 9
cell 11
exp 5
exp 8
exp 9
exp 11

Fig. 25

ISP37

calculated aerosol concentrations and exp.

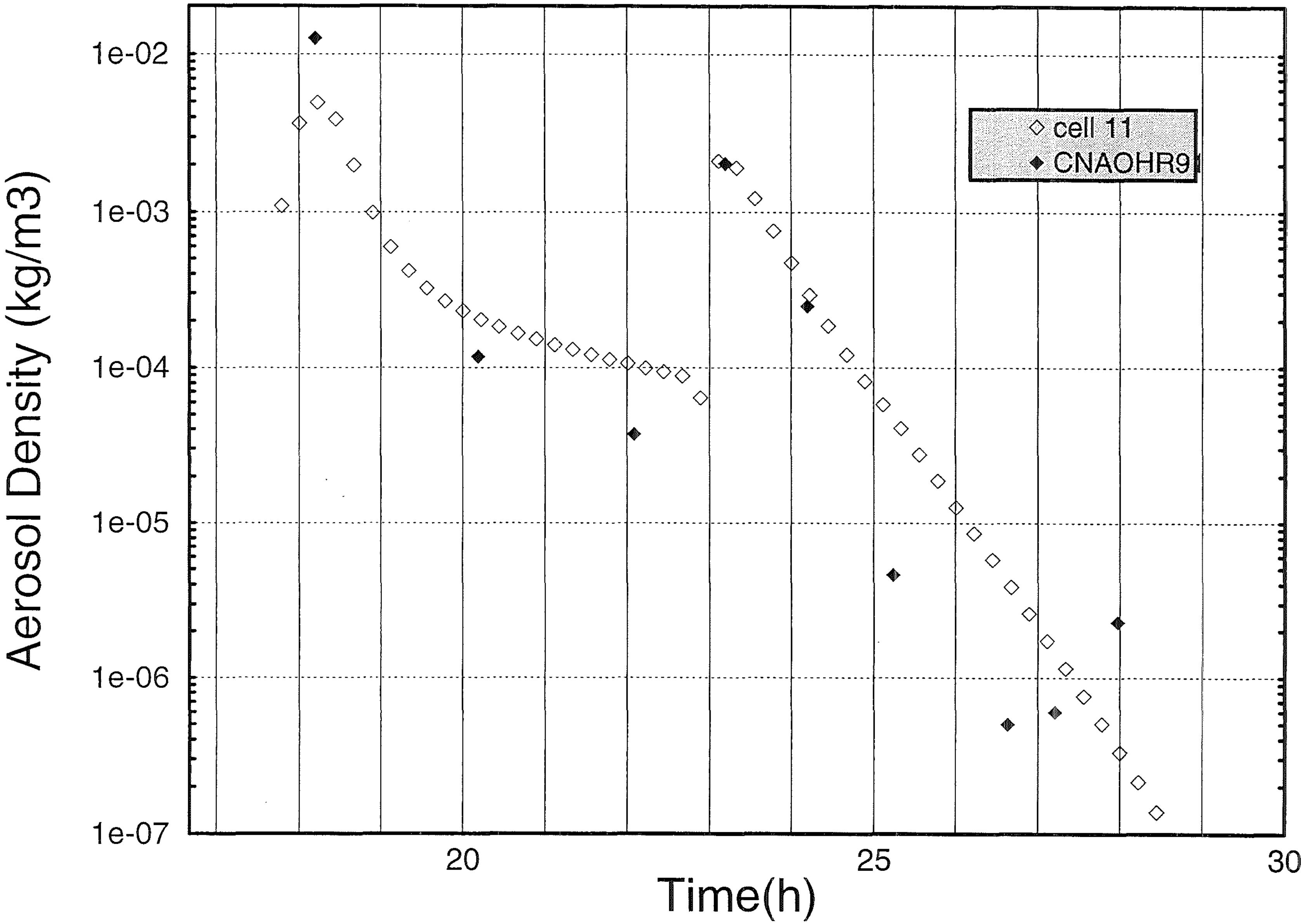
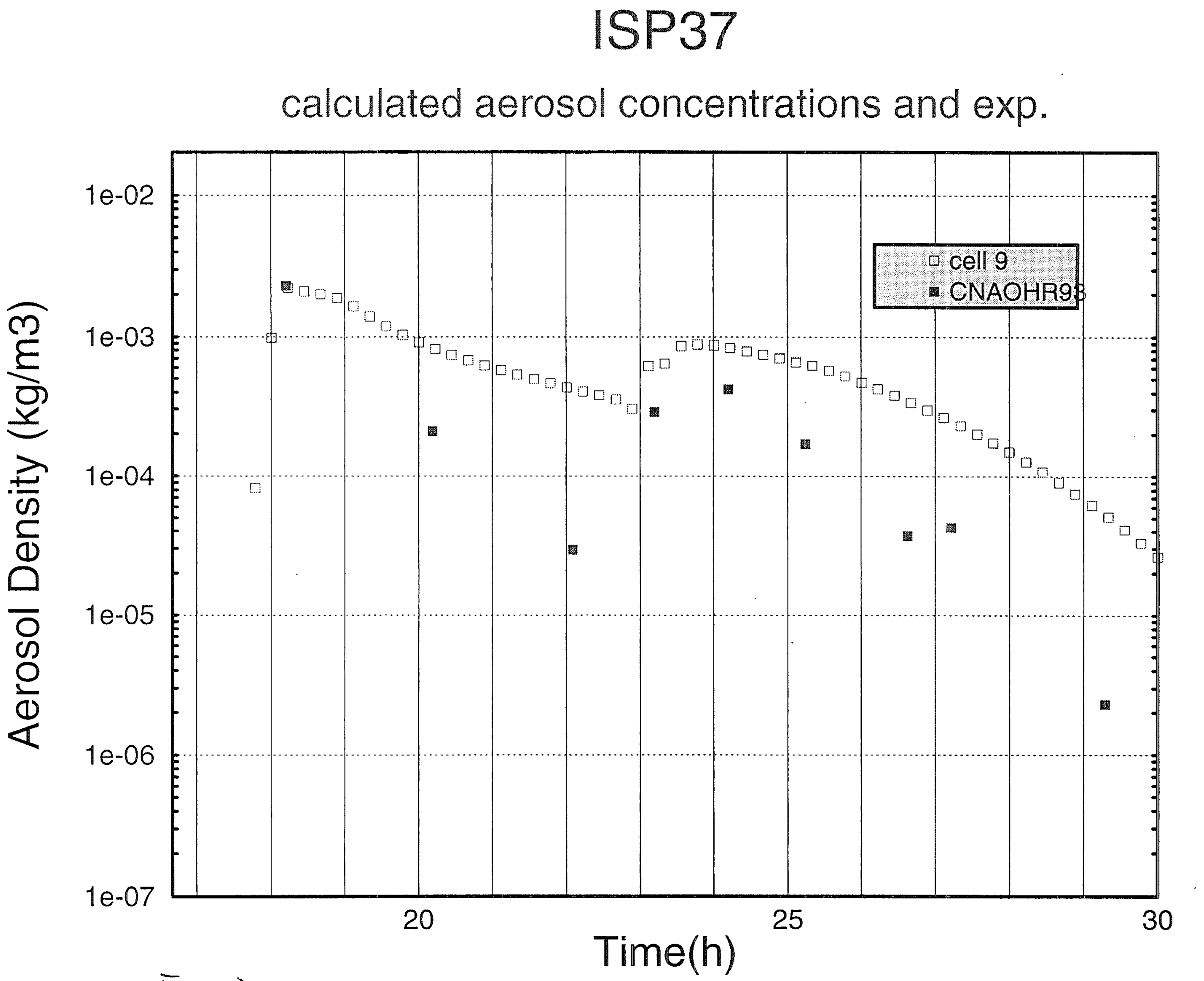


Fig. 26



ISP37
calculated aerosol concentrations and exp.
cell 9
CNAOHR93
1e-02
1e-03
1e-04
1e-05
1e-06
1e-07
Aerosol Density (kg/m3)
20
25
30
Time(h)

Fig. 27

ISP37

calculated aerosol concentrations and exp.

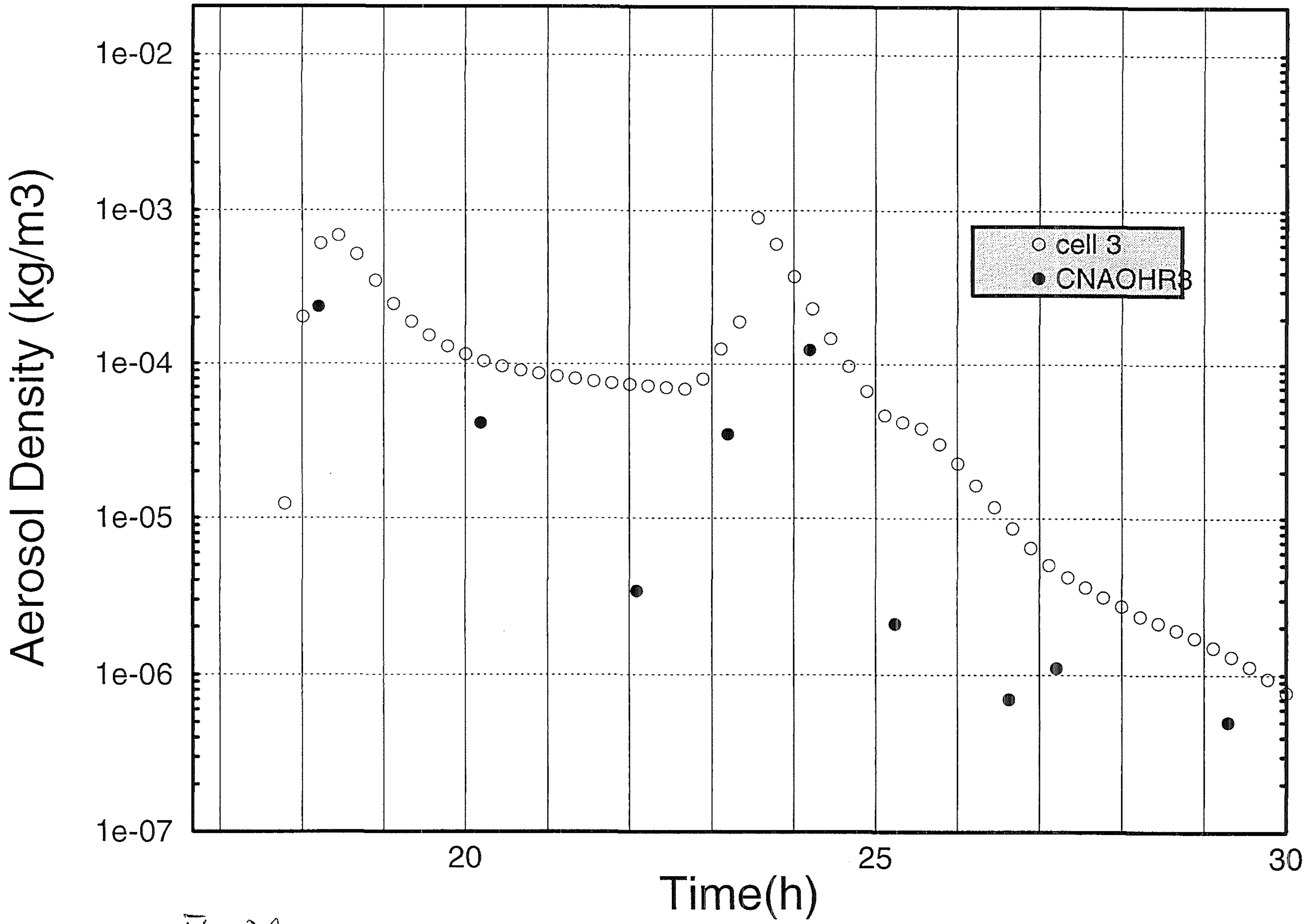


Fig. 28

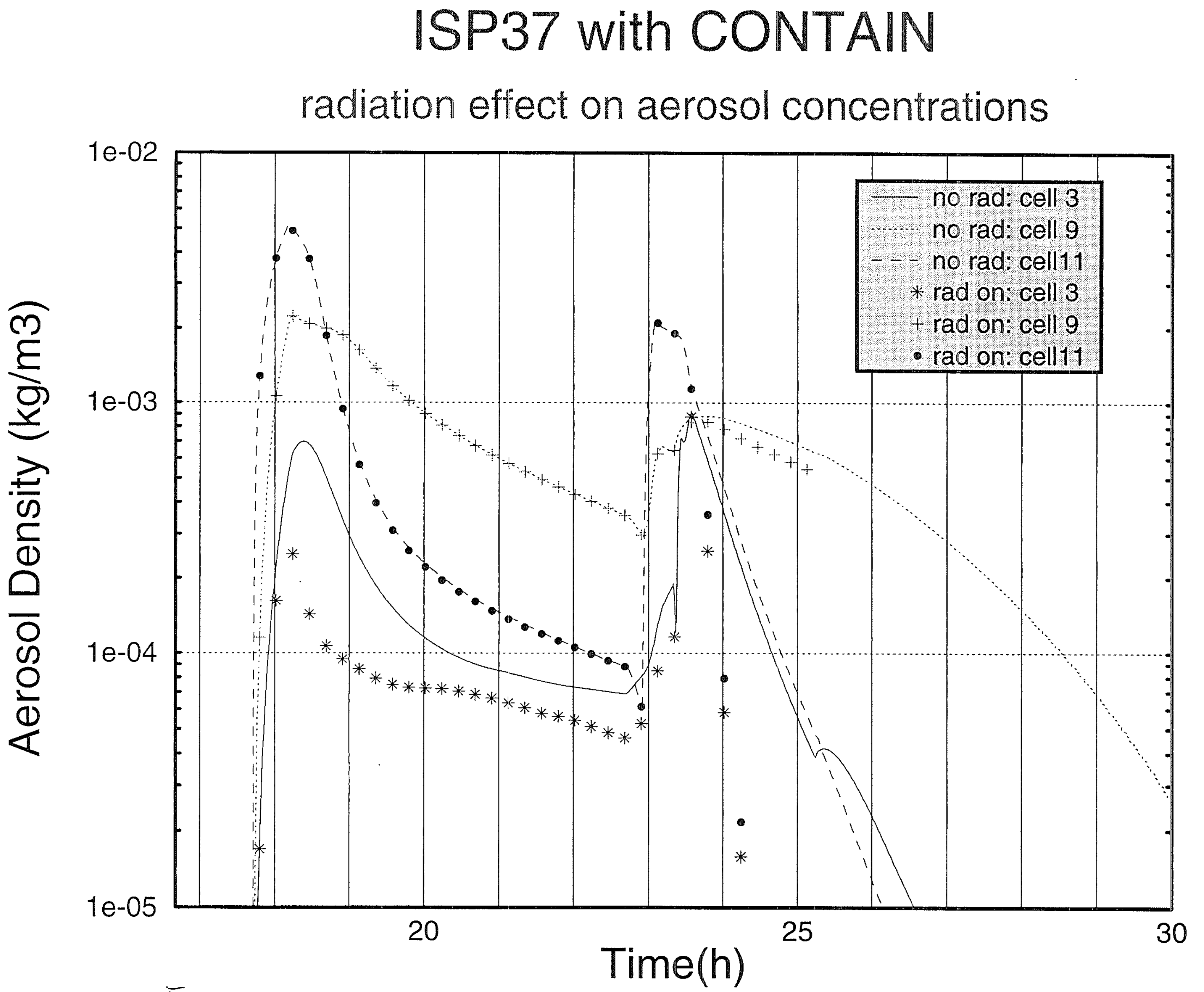

ISP37 with CONTAIN
radiation effect on aerosol concentrations
Aerosol Density (kg/m3)
1e-02
1e-03
1e-04
1e-05
no rad: cell 3
no rad: cell 9
no rad: cell11
rad on: cell 3
rad on: cell 9
rad on: cell11
20
25
30
Time(h)

Fig. 29

ISP37

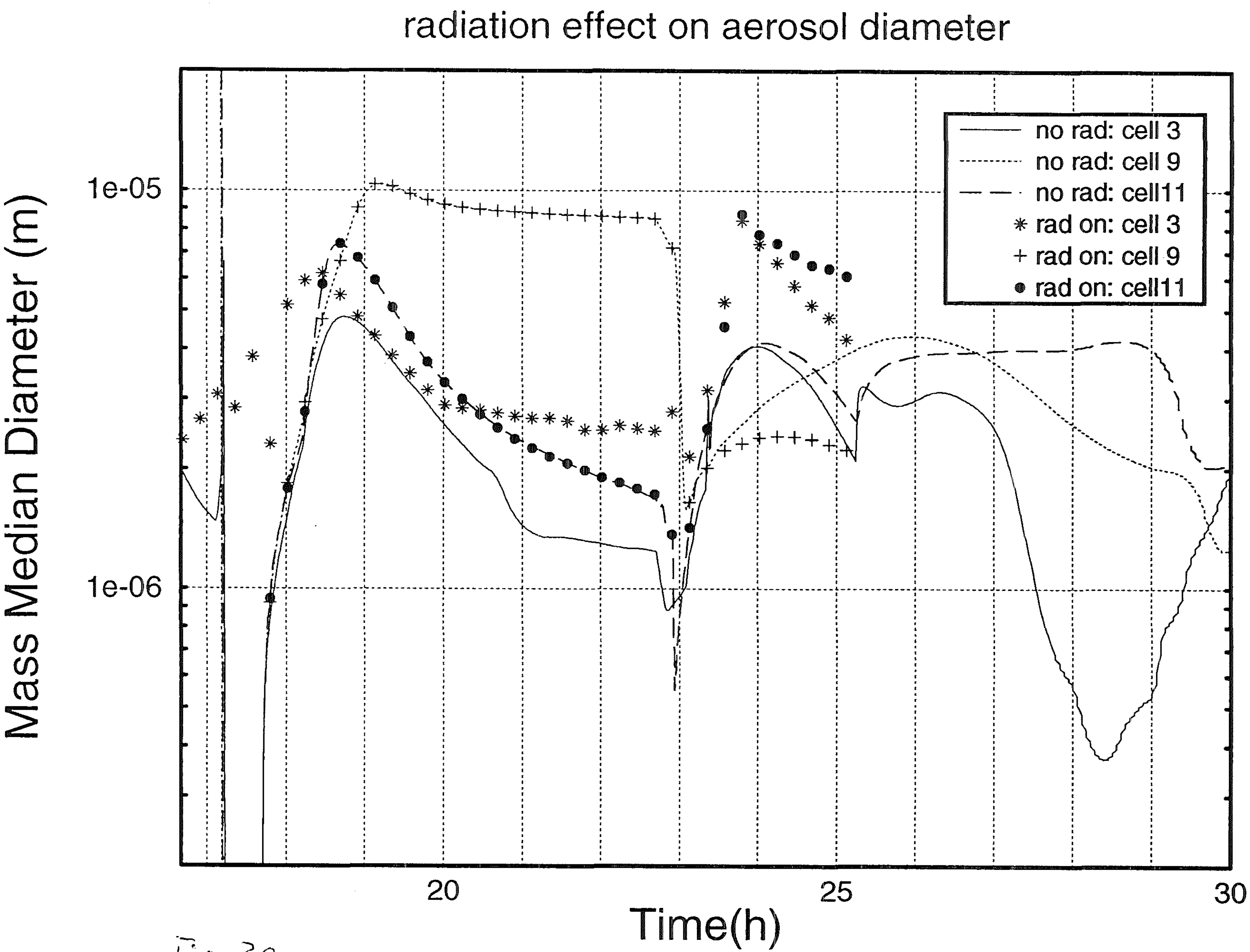

radiation effect on aerosol diameter
no rad: cell 3
no rad: cell 9
no rad: cell11
rad on: cell 3
rad on: cell 9
rad on: cell11
1e-05
1e-06
Mass Median Diameter (m)
20
25
30
Time(h)

Fig. 30