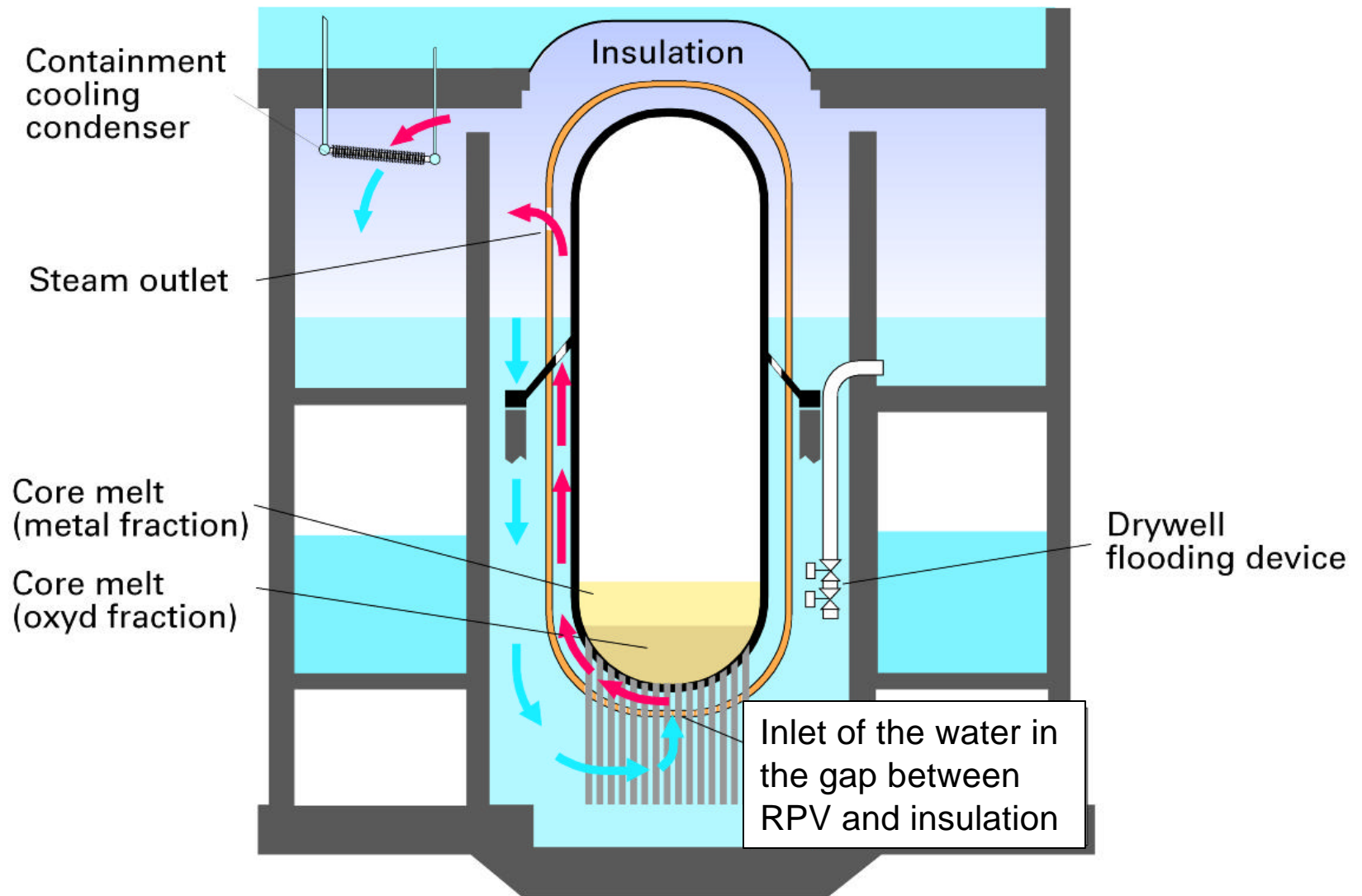




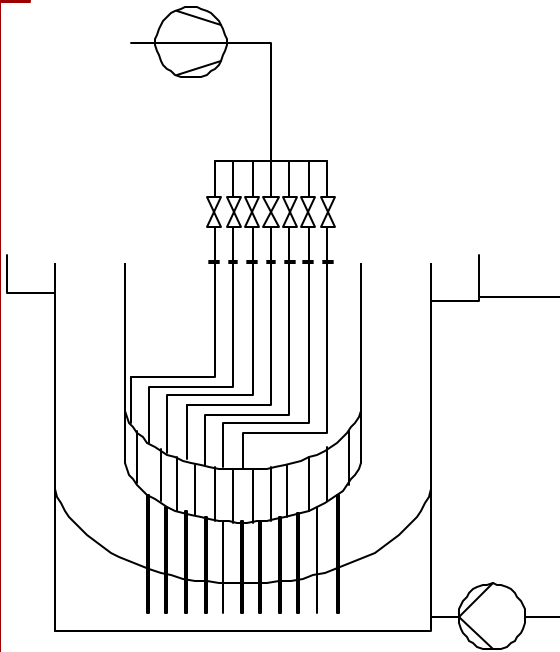
## ***SWR-1000: NRC-Visit***

Preparation of the External Vessel Cooling Test

# SWR 1000 - Exterior Vessel Cooling

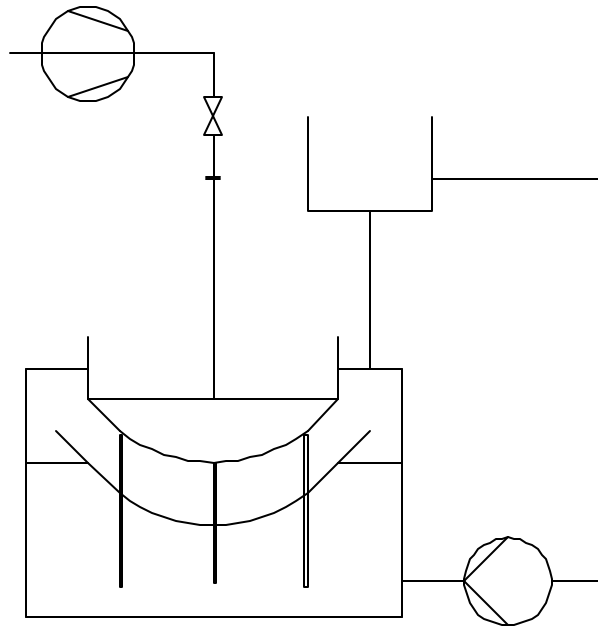


# Decoupling of Flow Conditions and Heat Transfer



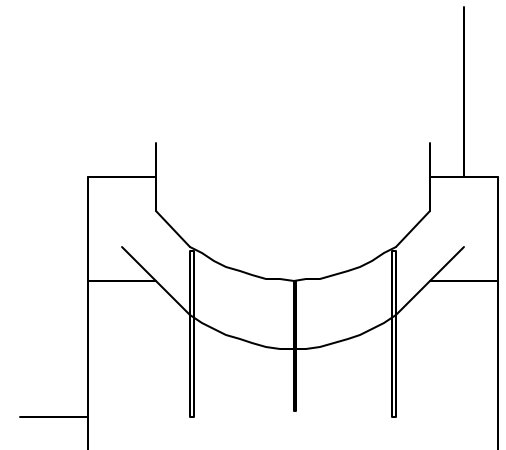
## **Water / Air-Experiments Scale 1 : 10**

Investigation of the global flow conditions and determination of requirements for the design of a segment



## **Water / Air-Experiments with a Section**

Designing of in- and outlets in order to reach a similar flow behaviour as in the global model



## **Water / Steam-Experiments with a Section**

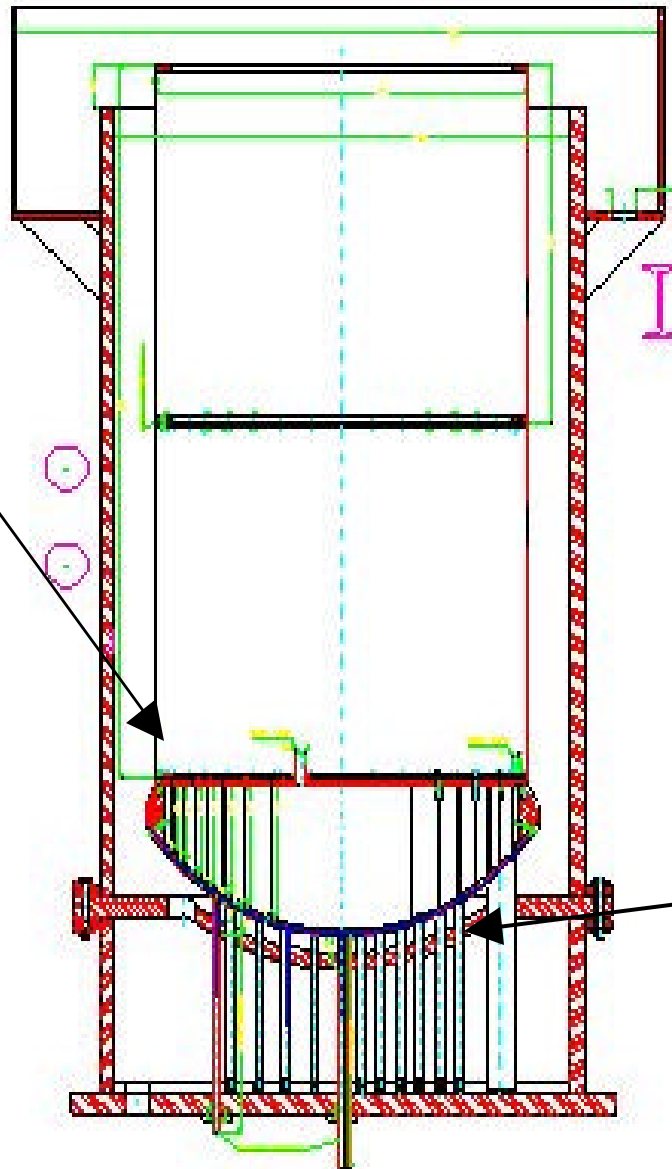
Measuring the Critical Heat Flux in a 1:1 section model installed in the BENSON test rig - a flexible water / steam test loop

## Global Model



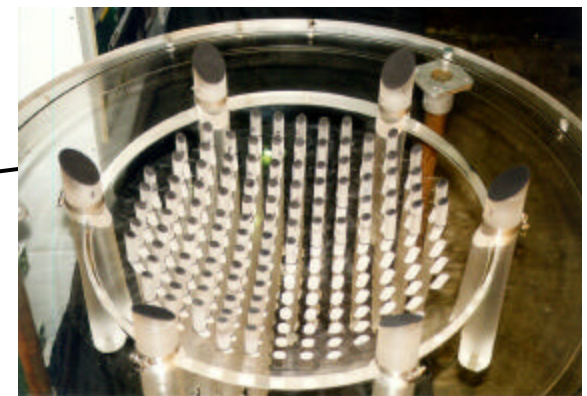
### Setup of the RPV:

- Air injection through a porous structure at the bottom
- Eight chambers with adjustable air supply

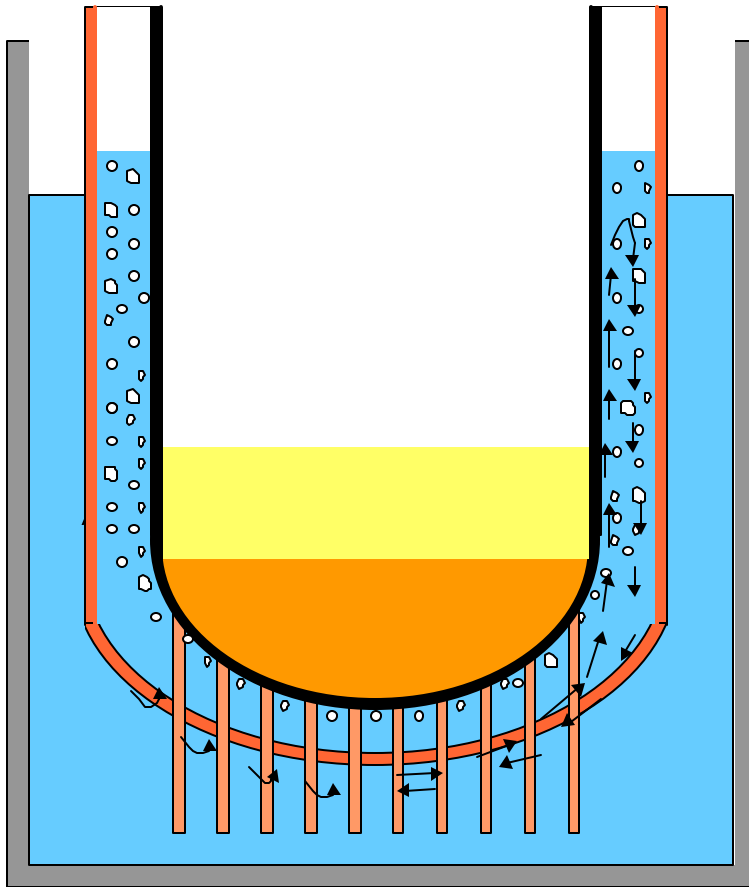


### Setup of the insulation:

- Transparent material including CRD and pump housings
- Impedance probes for measuring the adequate gas height
- Fiber optic probe for measuring the void

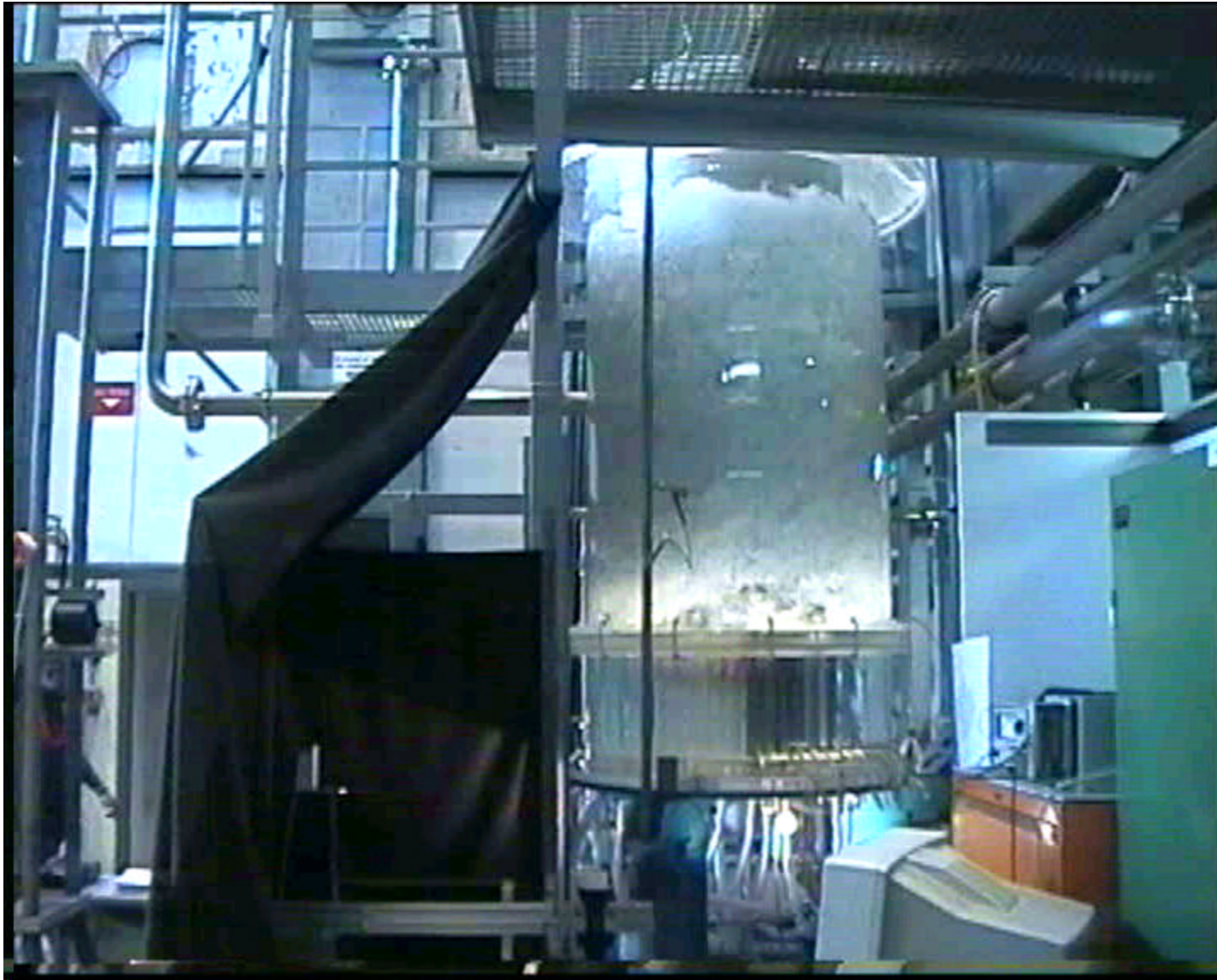


# Phenomenology



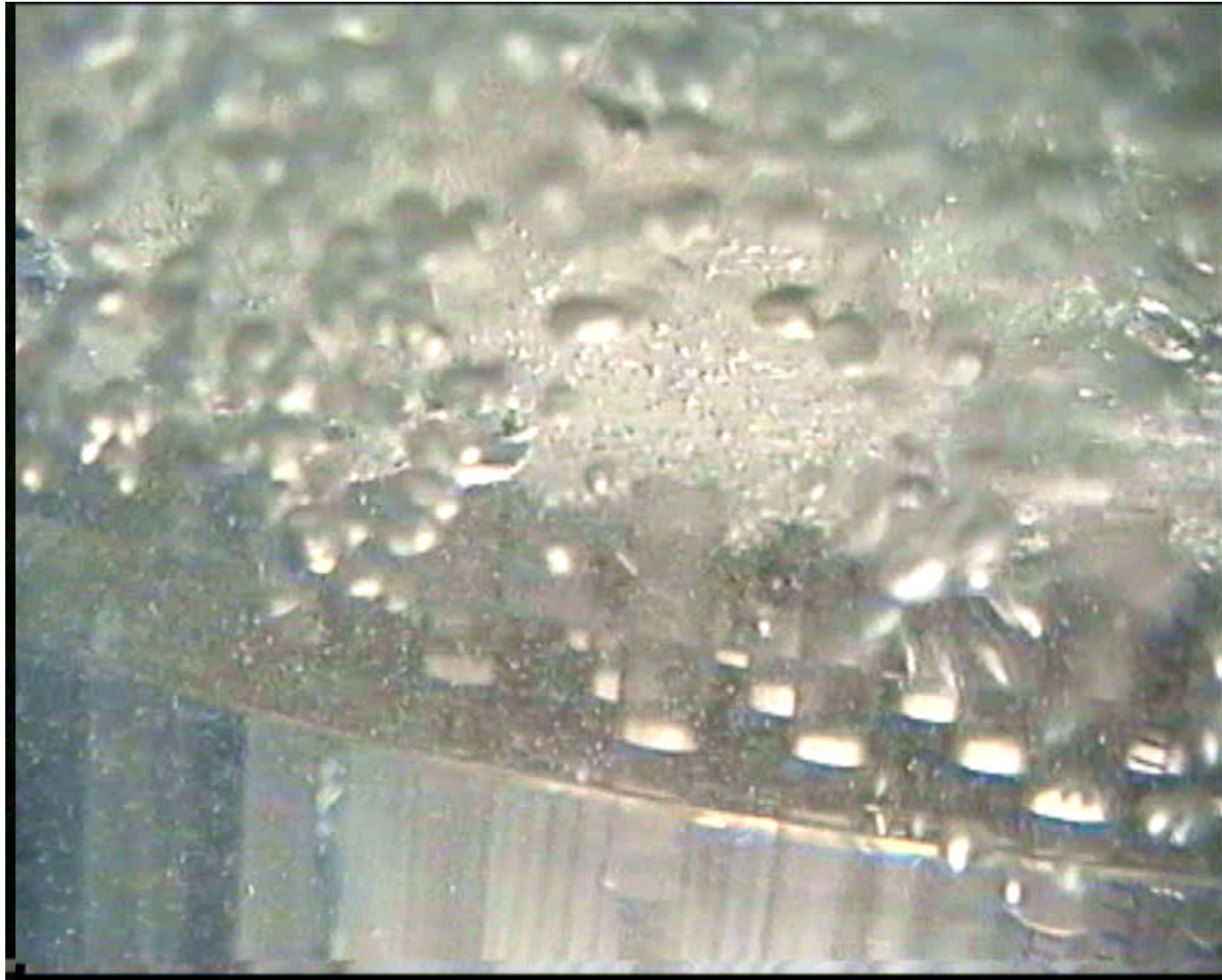
- Circulation can be observed  
The water / gas mixture will move upwards and will be separated at the swell level. The water will flow back
- Counter current flow can be observed at the bottom  
The water/air mixture flows upwards around the RPV, single-phase water flows downwards around the insulation. A portion penetrates in the water/air mixture
- Flow is approximately rotational symmetric
- Bubbles in the water/air test grow approximately similar to those of boiling tests
- Rotational symmetric slug bands will be formed. In the case of flow without insulation, they are stronger than in the case with insulation

## Phenomenology - Global Model in Operation

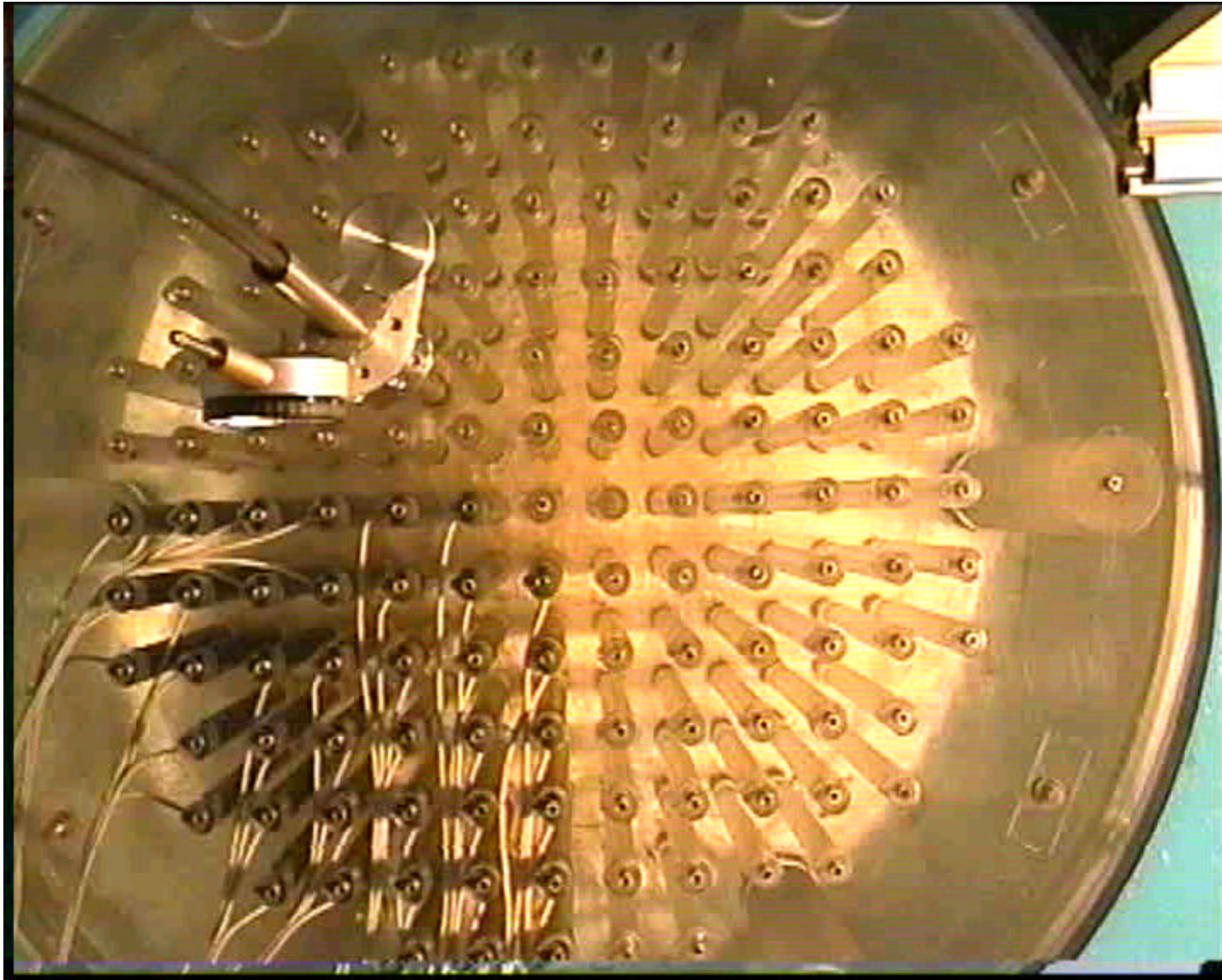




## Phenomenology - Counter Current Flow

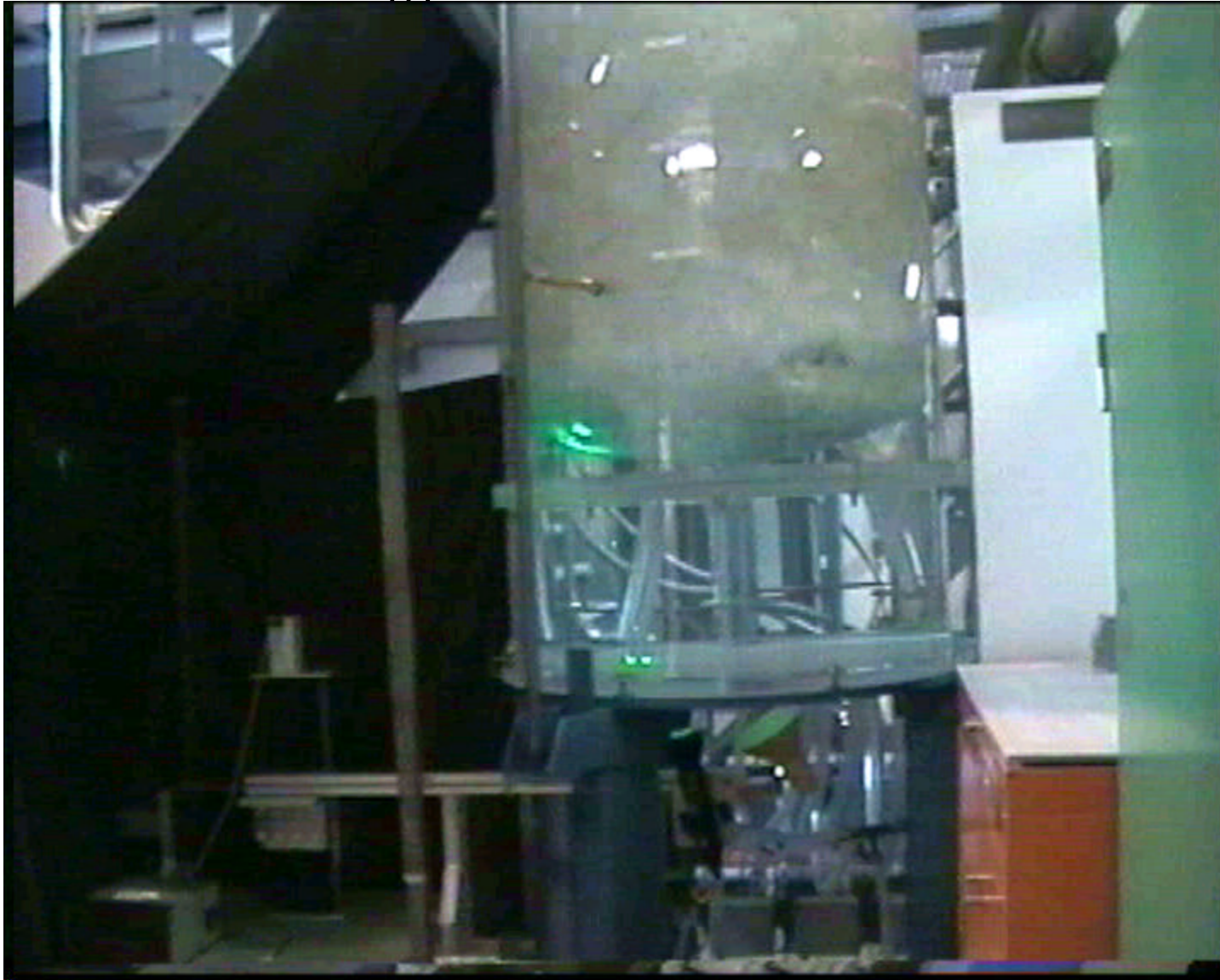


## Phenomenology - Flow around the CRD Housings

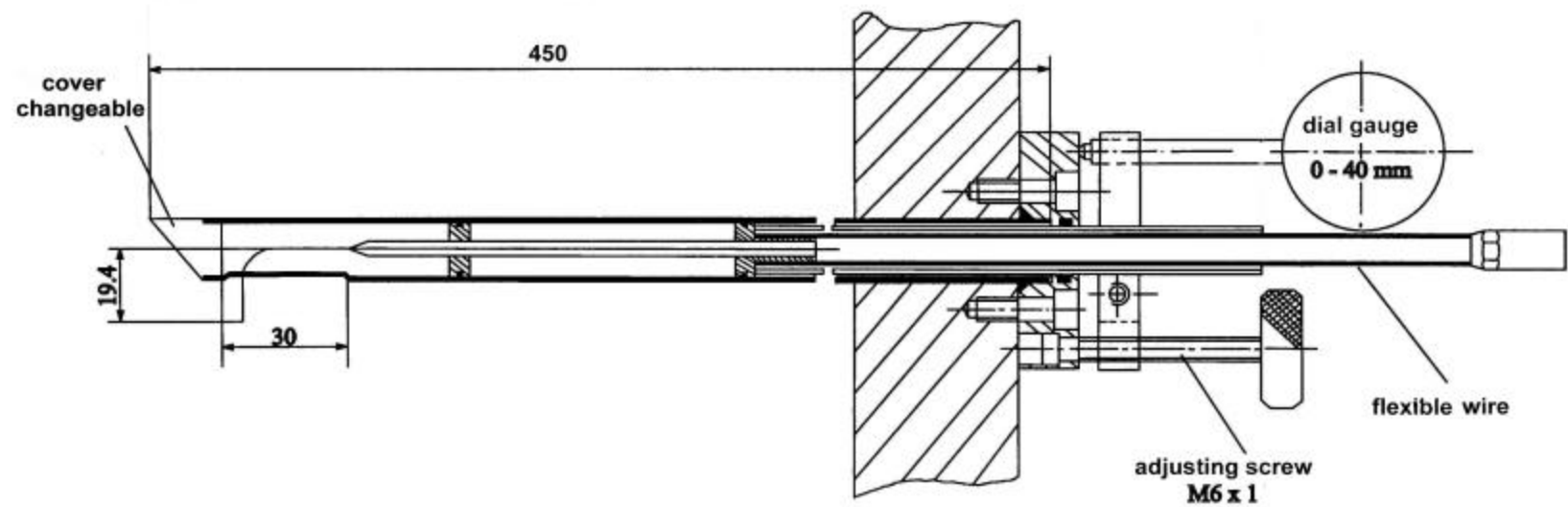




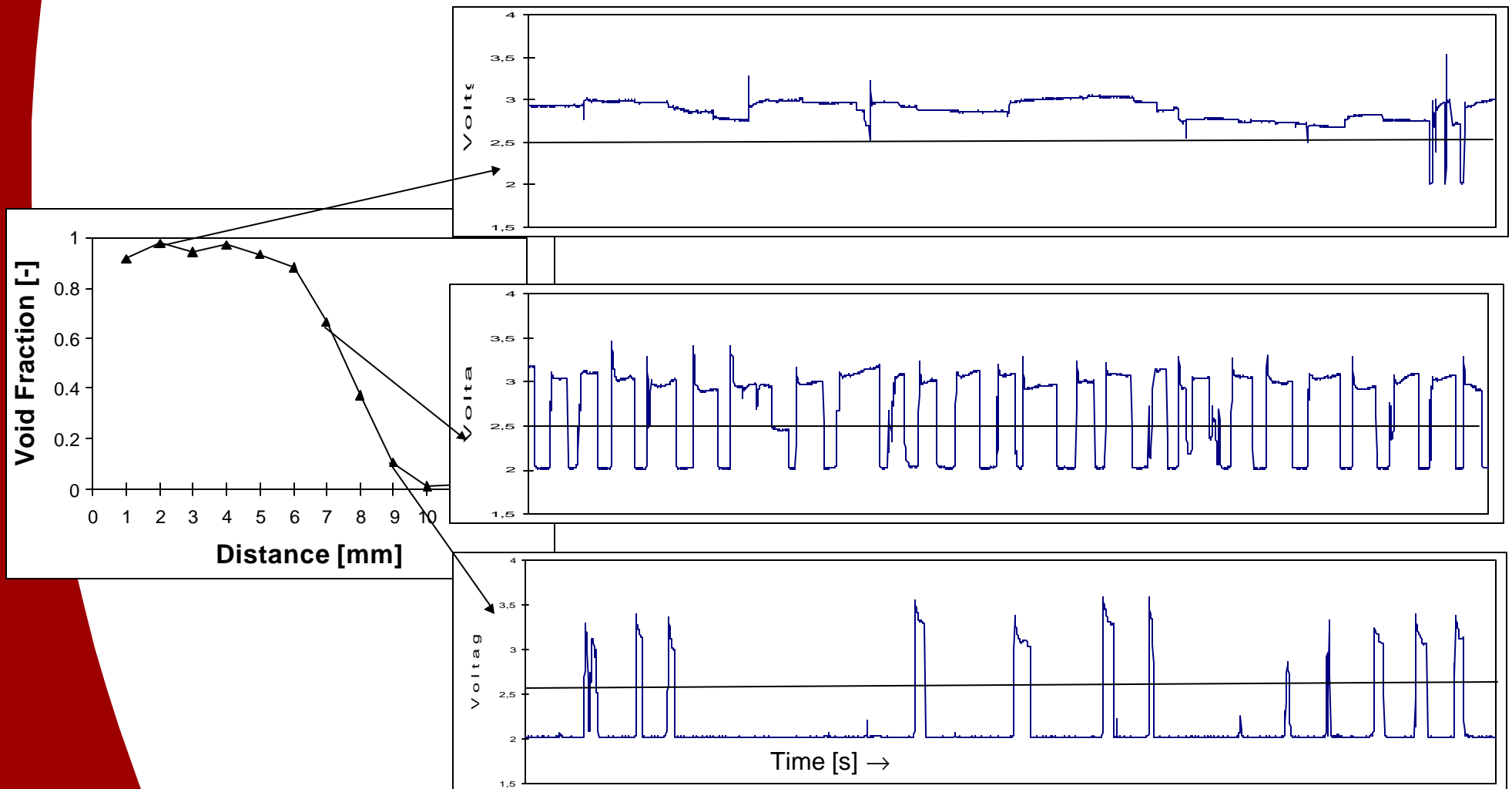
## Phenomenology - Movement of Bubbles



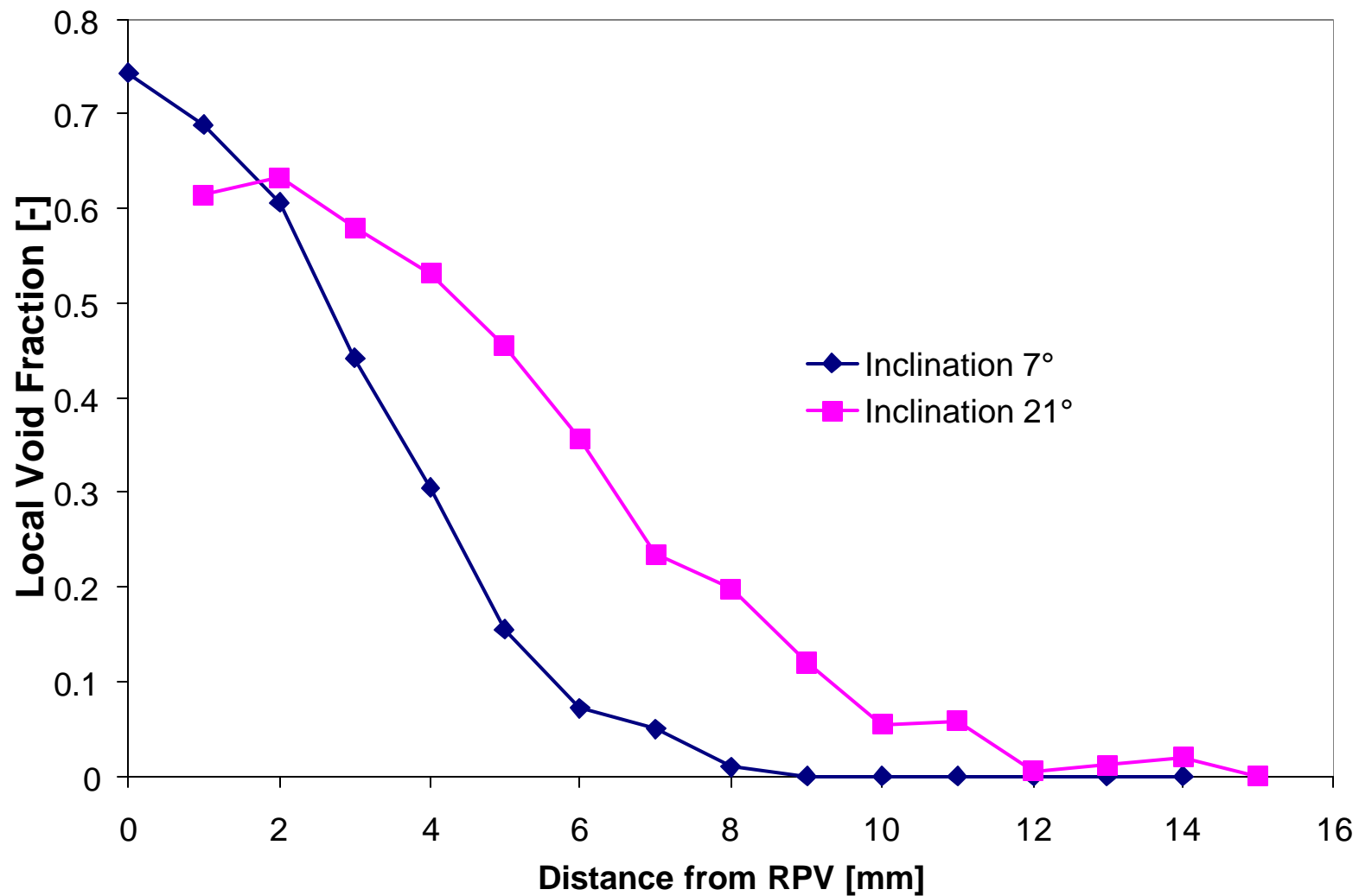
# Fiber Optic Probe



# Local Void Fraction Determination

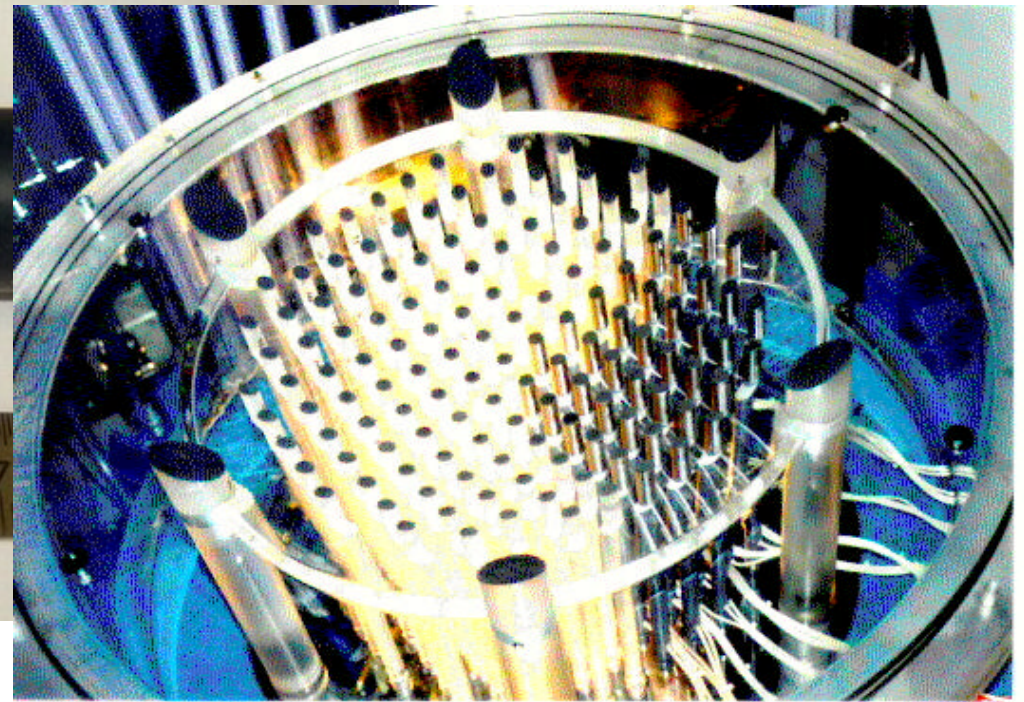
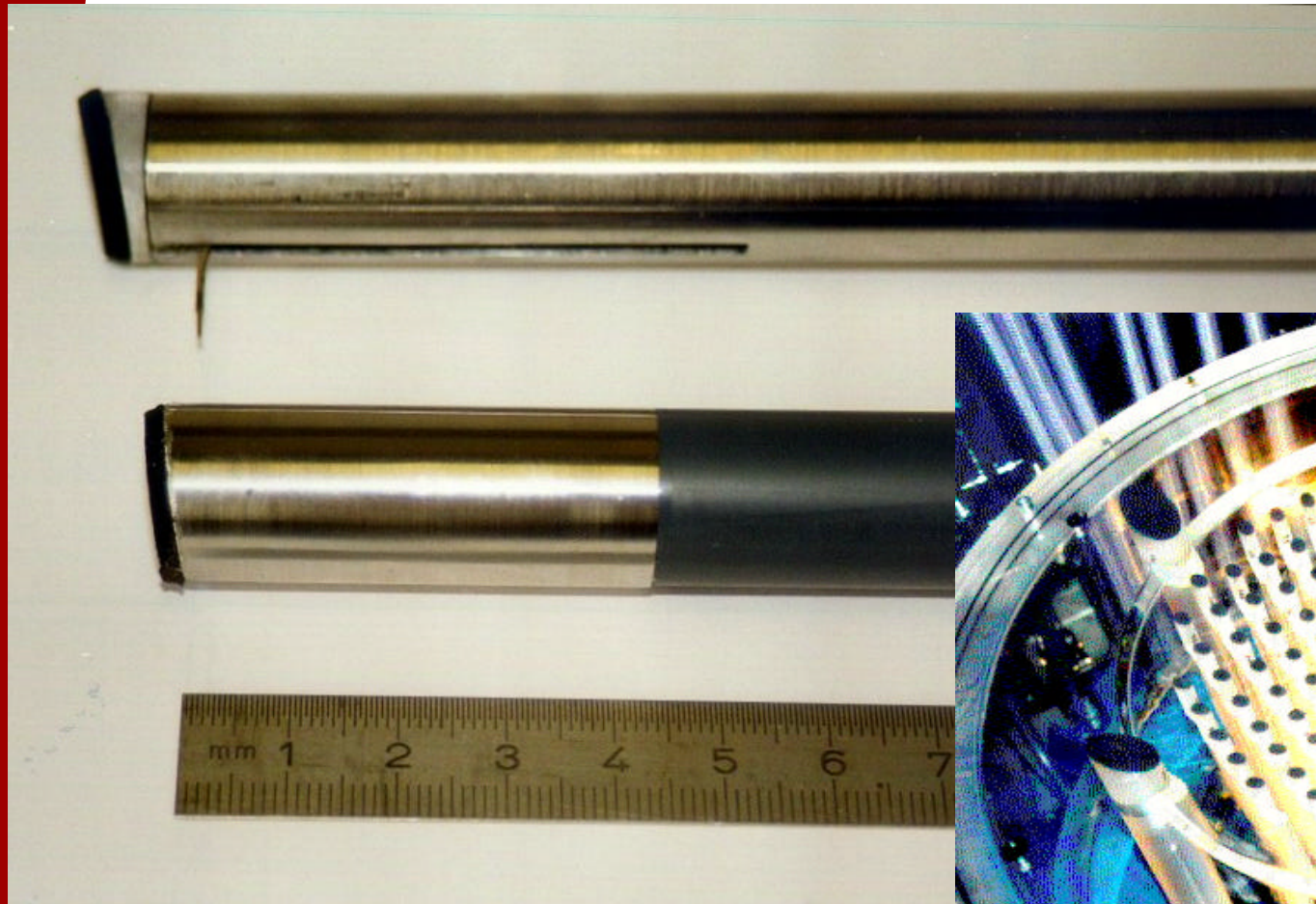


## Local Void Fractions at different Inclinations

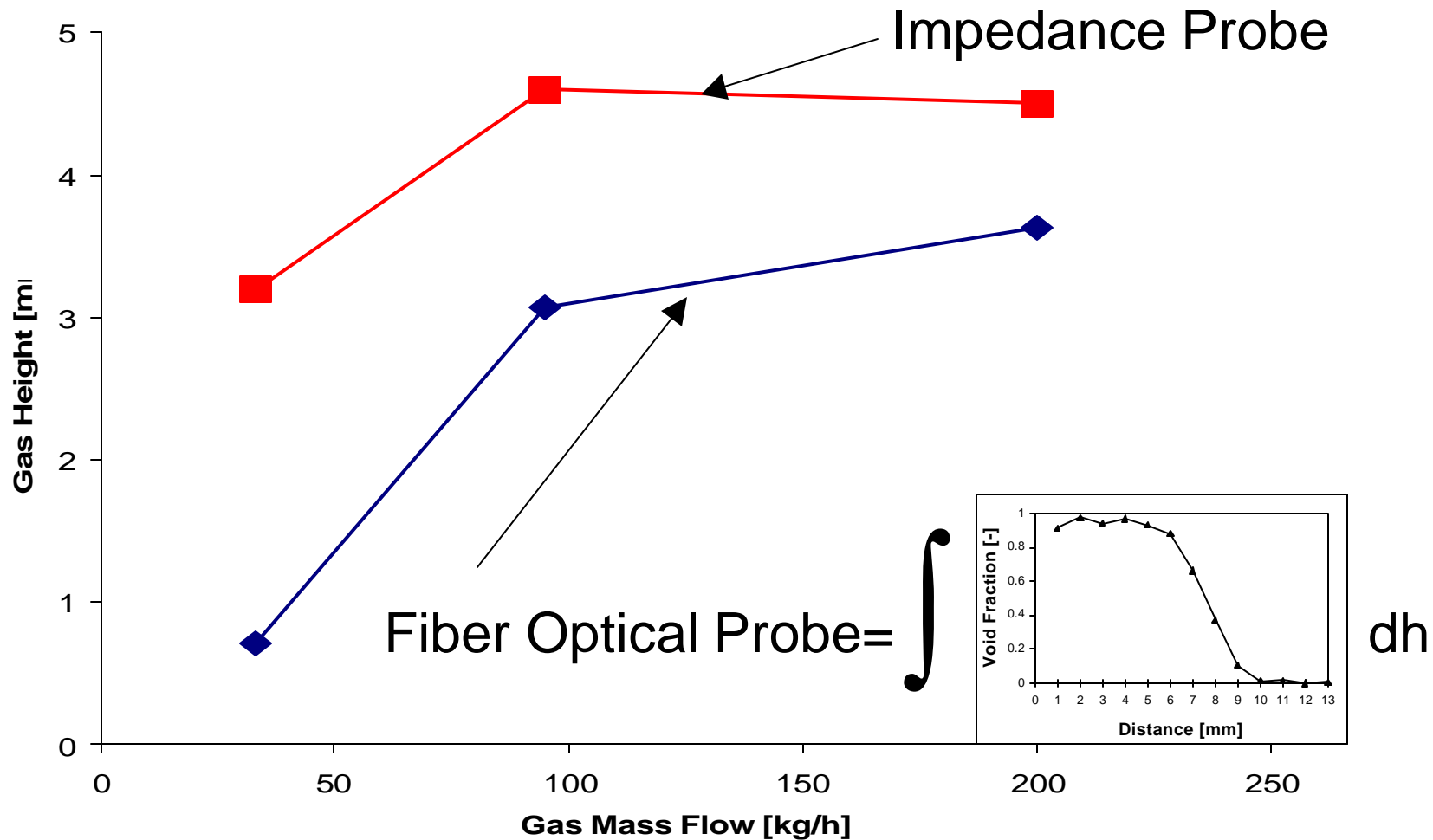




## Dimension and Positions of the Probes

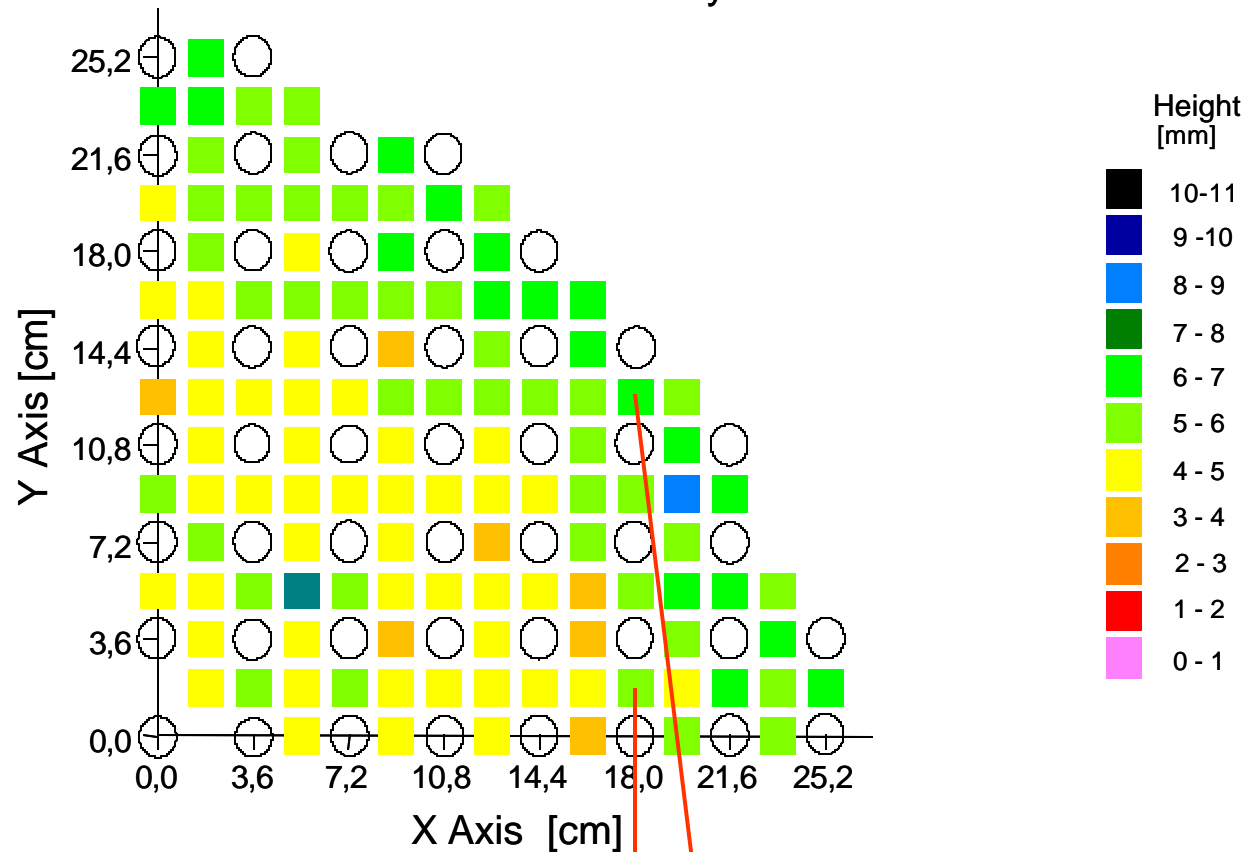


# Average Gas Height measured with Fiber Optic Probe and Impedance Probe



# Gas Height Distribution

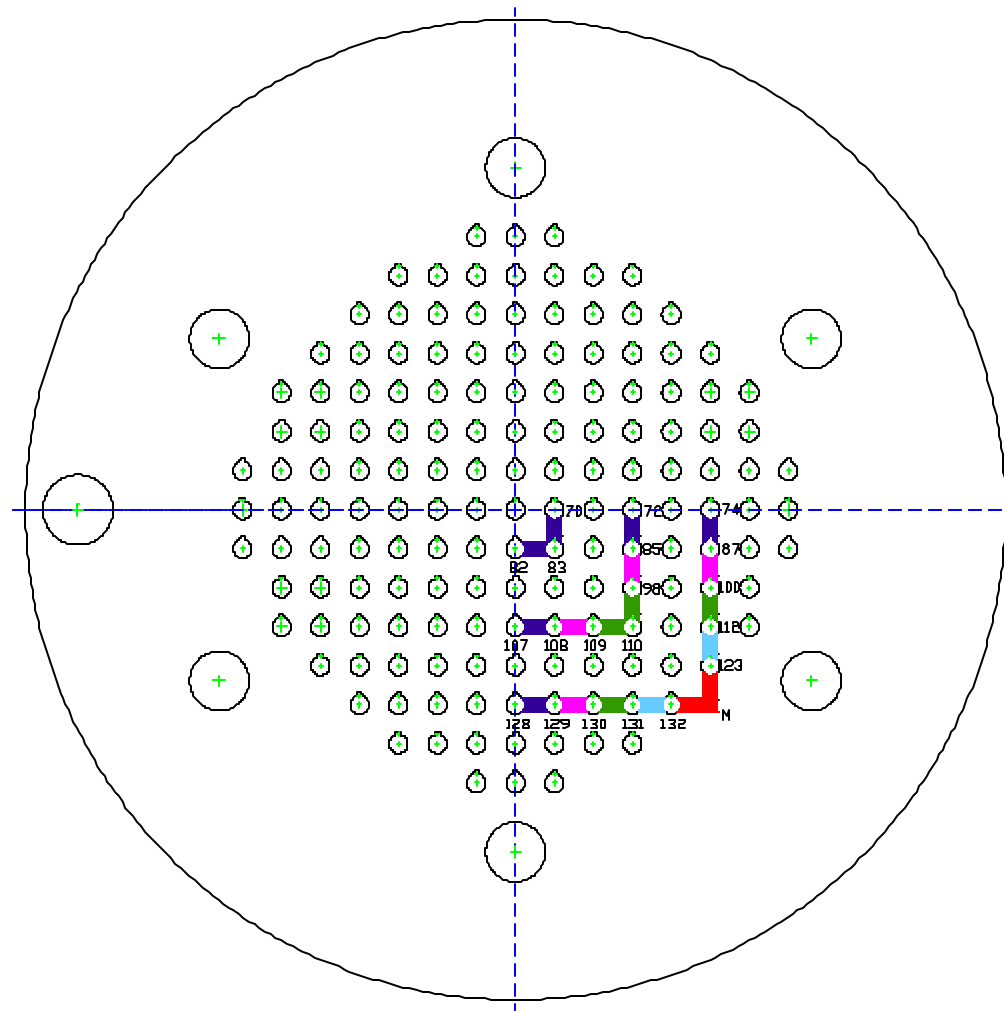
Adequate Gas Height at a Mass Flux of Decay Heat



Adequate Gas height between CRD Housing No. 131 and No. 132 (6 -7 mm)

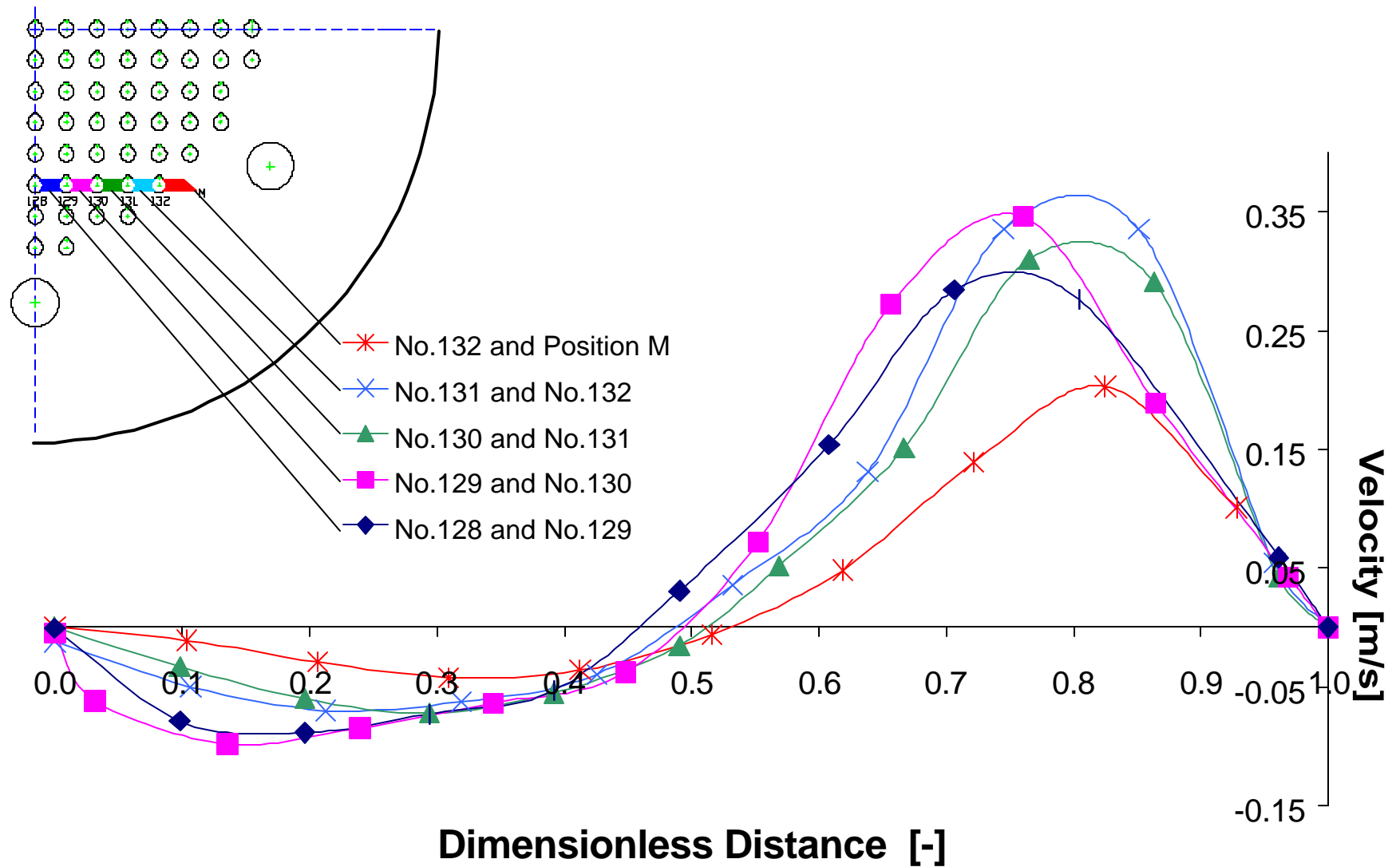
Adequate Gas height between CRD Housing No. 128 and No. 129 (5 -6 mm)

## Positions of the LDA Measurements

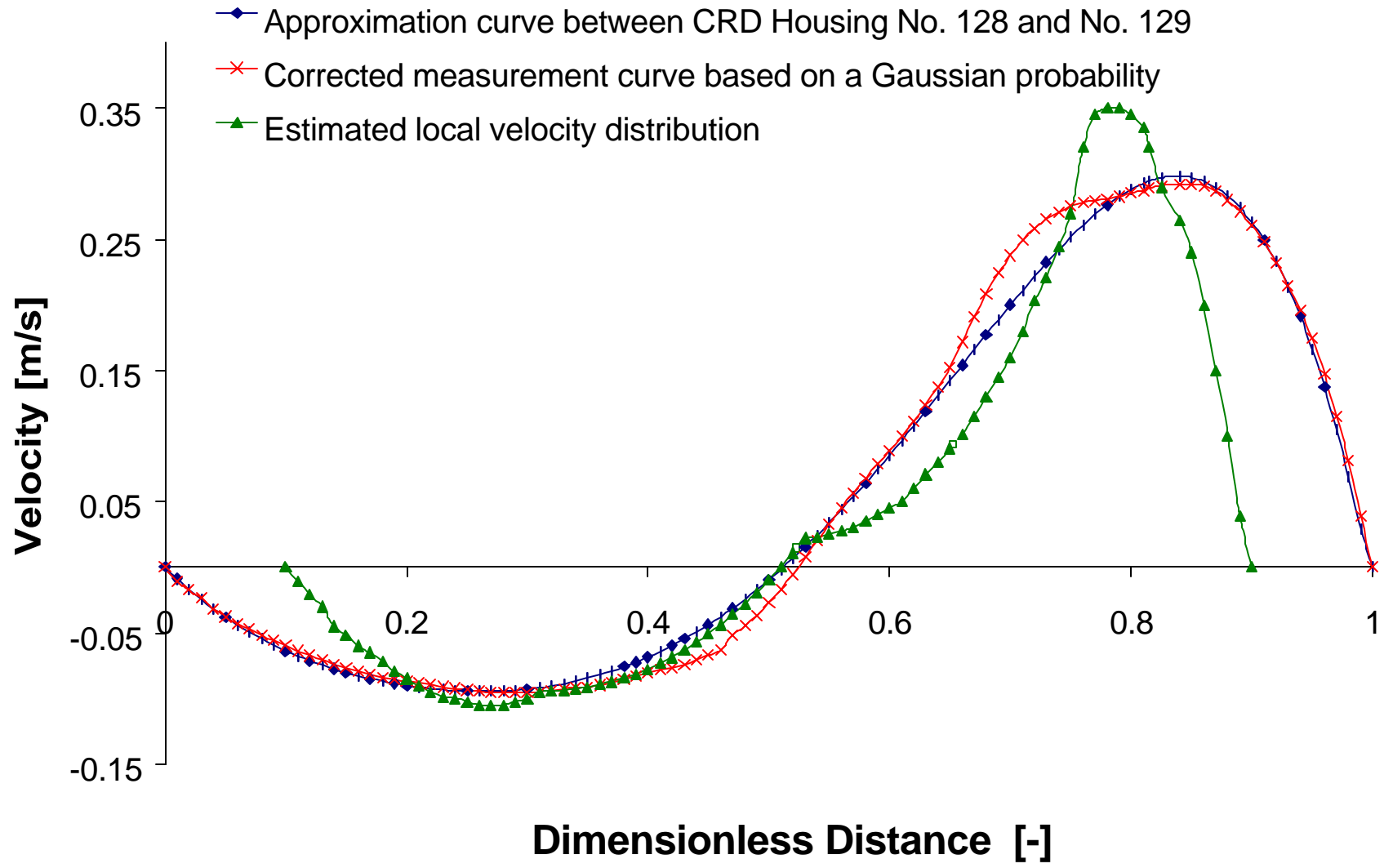




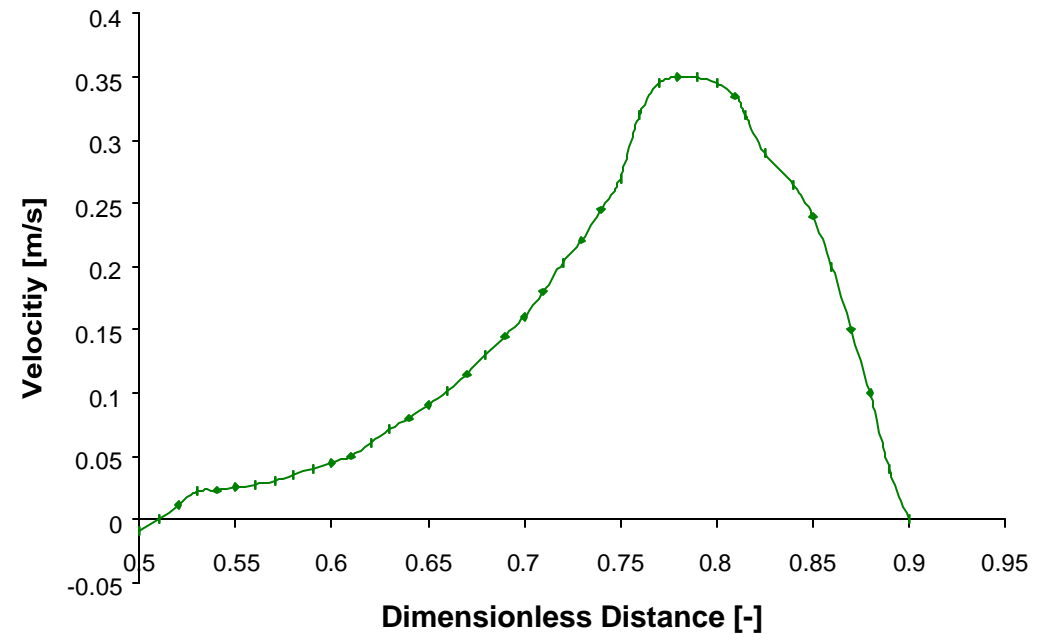
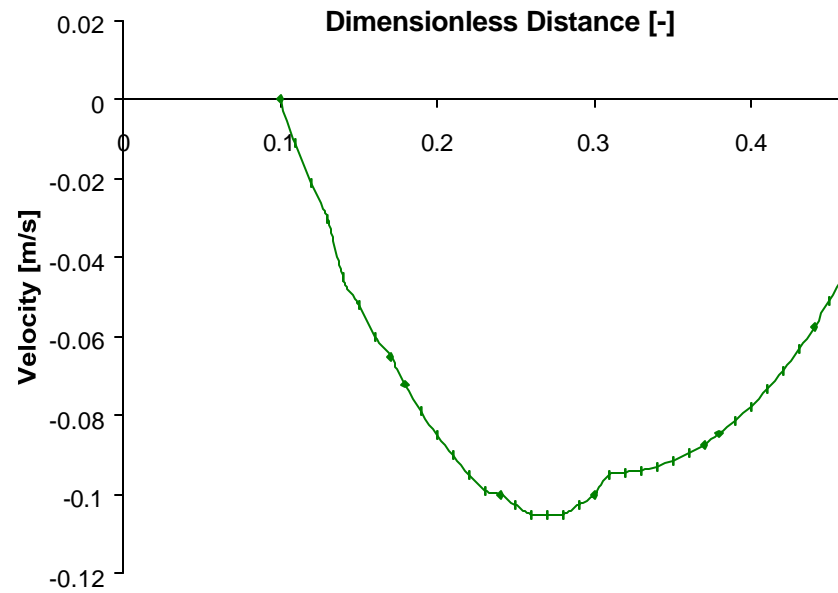
# Velocity Distribution as the Function of the Height



# Local Velocities



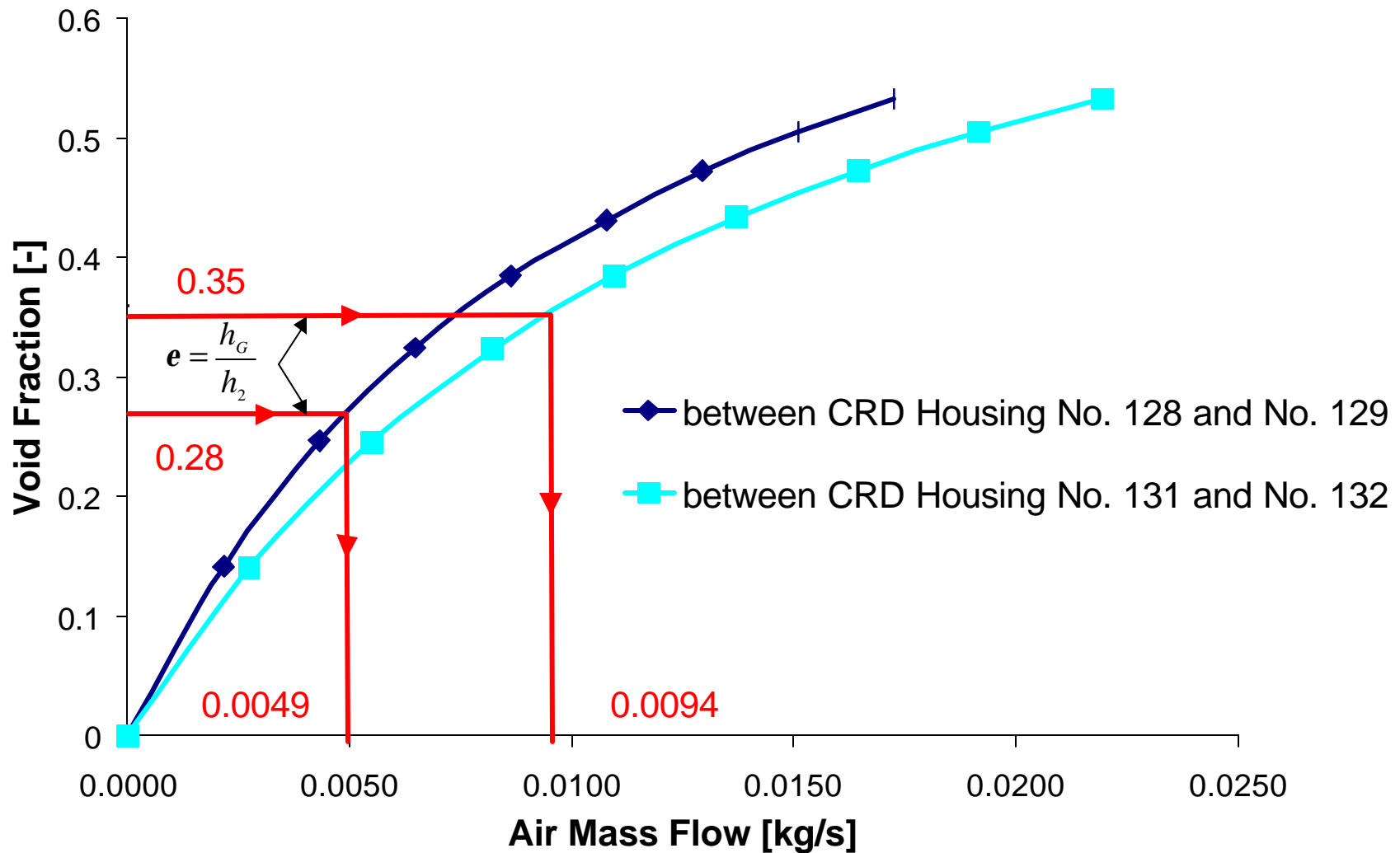
# Water Mass Flow Balance



$$\dot{M}_{W,in} = \left\{ \sum_{i=1}^{\text{Number of positions in the area with negative velocities}-1} \left[ (x_{i+1} - x_i) (v_i (\mathbf{e}_i - 1) + v_{i+1} (\mathbf{e}_{i+1} - 1)) \mathbf{r}_L \frac{1}{2} \right] \right\} b (-1) =$$

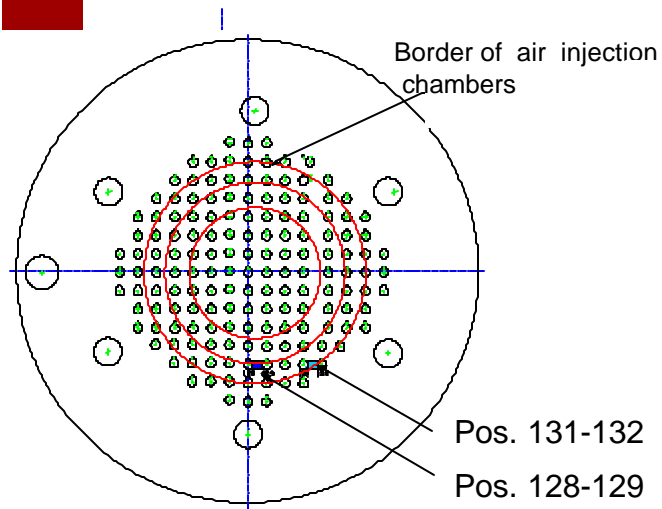
$$\dot{M}_{W,out} = \left\{ \sum_{i=1}^{\text{Number of positions in the area with positive velocities}-1} \left[ (x_{i+1} - x_i) (v_i \cdot (\mathbf{e}_i - 1) + v_{i+1} \cdot (\mathbf{e}_{i+1} - 1)) \mathbf{r}_L \frac{1}{2} \right] \right\} b$$

# Gas Mass Flow Balance



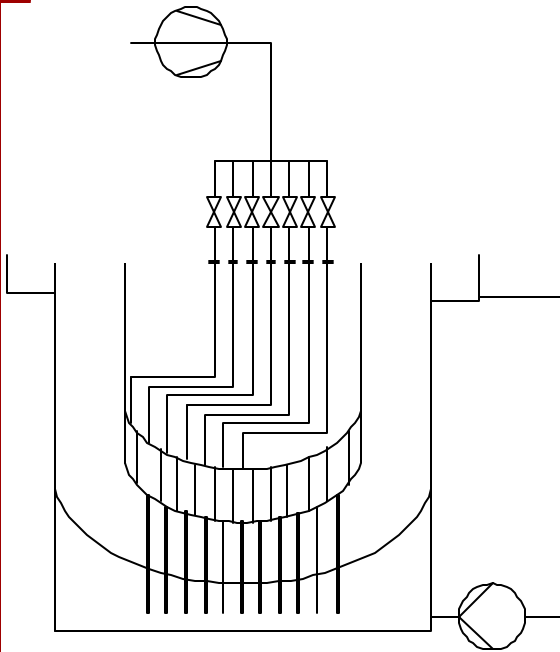


# Results of the Mass Flow Balances



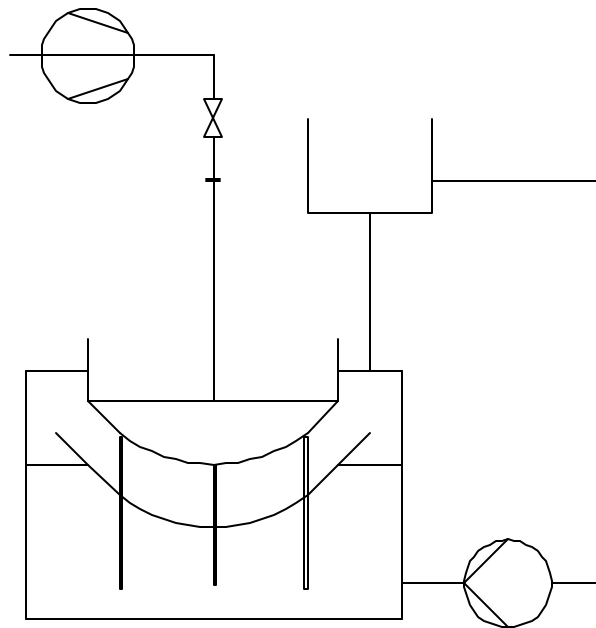
	Position 128-129	Position 131-132
Water Mass Flow, Inlet [kg/s]	1,19	1,36
Water Mass Flow. Outlet [kg/s]	1,40	1,59
Ratio Water Mass Flow Out/In	1,18	1,17
Air Mass Flow, Injected [kg/s]	0,0043	0,0085
Air Mass Flow, Acc. Fig. 13 [kg/s]	0,0049	0,0094
Ratio Out/In	1,14	1,11

# Decoupling of Flow Conditions and Heat Transfer



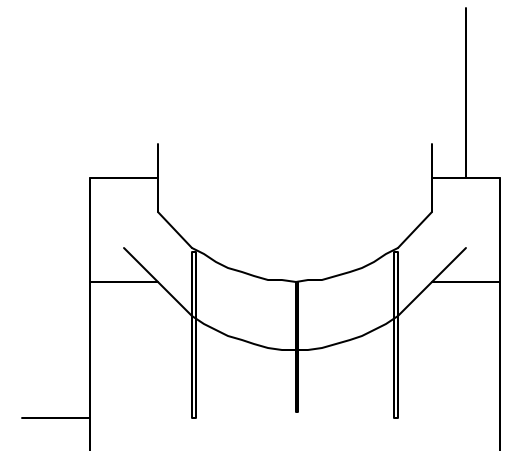
## **Water / Air-Experiments Scale 1 : 10**

Investigation of the global flow conditions and determination of requirements for the design of a segment



## **Water / Air-Experiments with a Section**

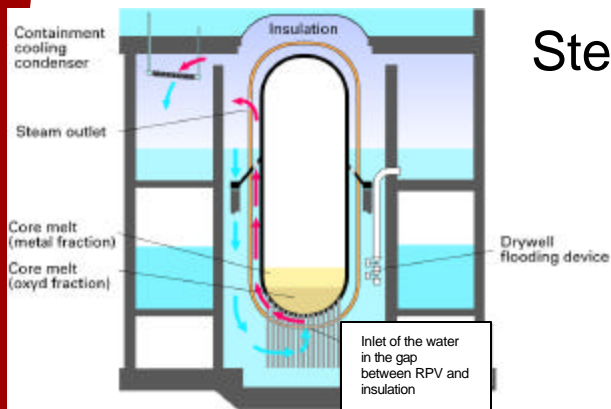
Designing of in- and outlets in order to reach a similar flow behaviour as in the global 1 : 1 model



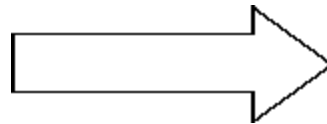
## **Water / Steam-Experiments with a Section**

Measuring the Critical Heat Flux in a 1:1 Section Model installed in the BVS - a flexible Water / Steam-Test Loop

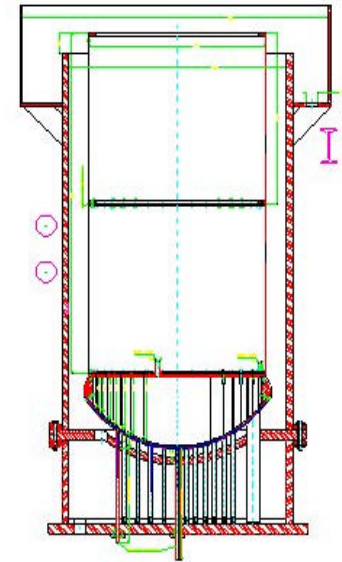
# Scaling Procedure and Intention



Steam generation



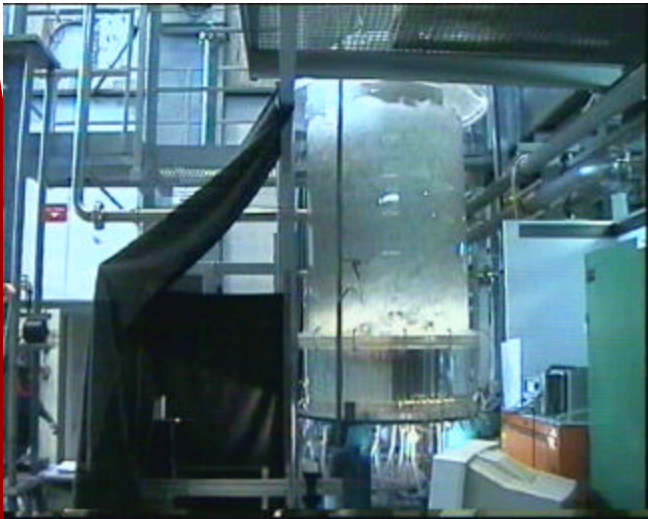
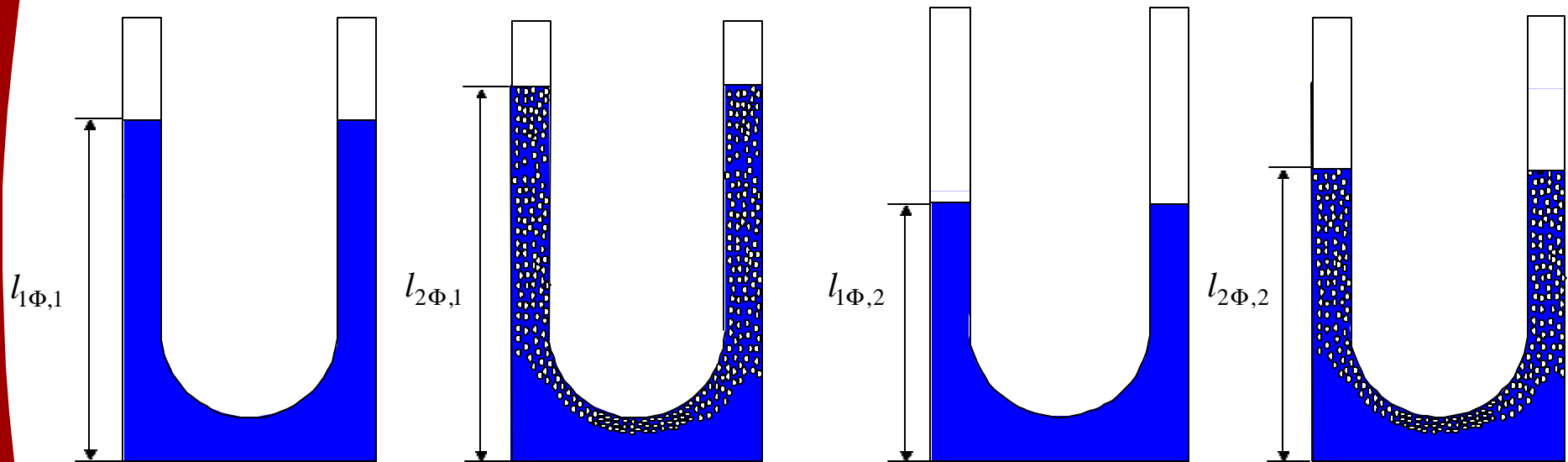
Air injection



Procedure:

- Void measurements in the model
- Approximation of drift flux correlation parameters
- Calculation of the void fraction based on the new correlation
- Calculation of the air mass flow with similar void fraction

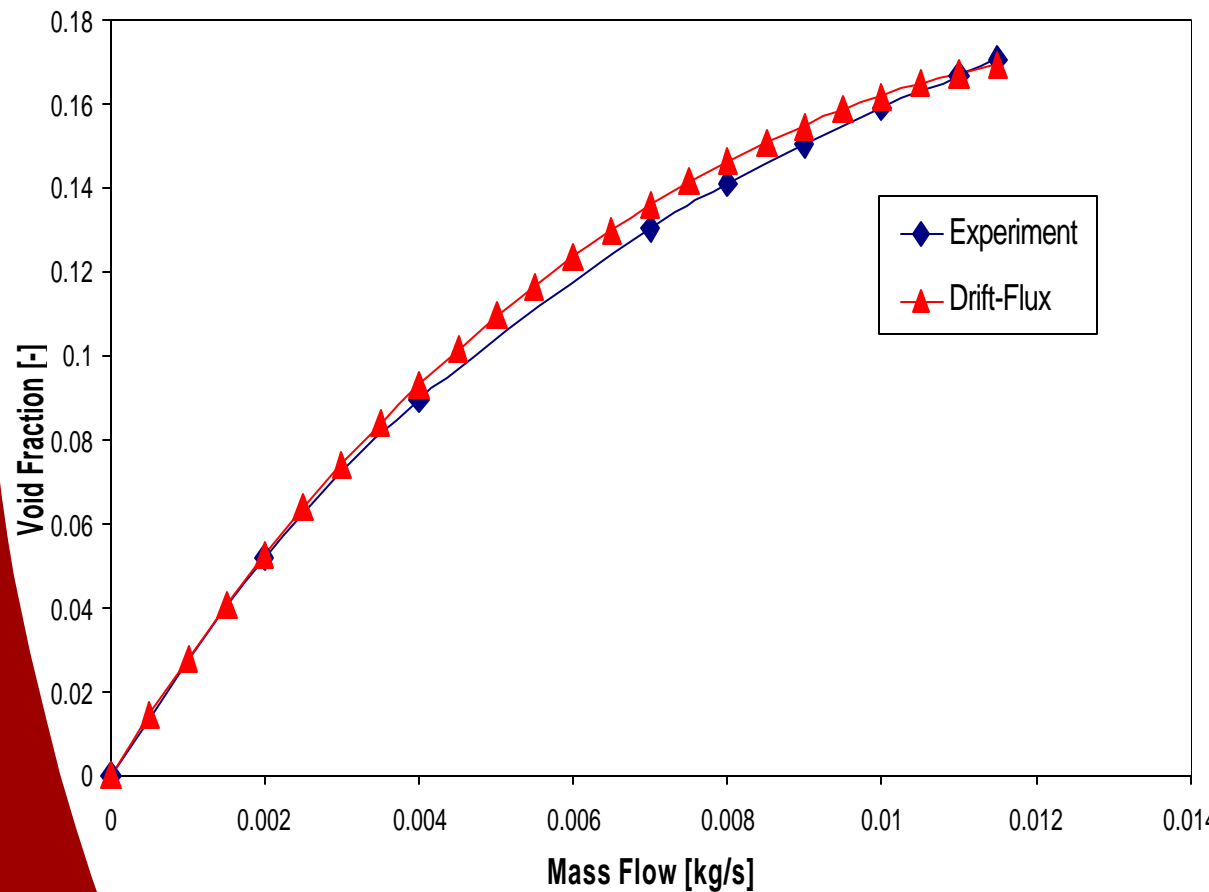
# Void Fraction Measurement Method



$$e = \frac{(l_{2\Phi,1} - l_{1\Phi,1}) - (l_{2\Phi,2} - l_{1\Phi,2})}{(l_{2\Phi,1} - l_{1\Phi,1}) - (l_{2\Phi,2} - l_{1\Phi,2}) + (l_{1\Phi,1} - l_{1\Phi,2})}$$



# Measured Void Fraction and Developed Correlation



$$e = \left( \frac{C_0}{e_{\text{hom}}} + \frac{\mathbf{r}_g^* u_{gi}}{\dot{x}^* \dot{m}} \right)^{-1}$$



$$C_0 = 3,03654$$

$$u_{gi} = 0,77575 * \left[ \frac{\rho^* g^* (\tilde{n}_l - \tilde{n}_g)}{\tilde{n}_l^2} \right]^{0,25}$$



$$e = \left( 3,03654 + \frac{\mathbf{r}_g^* 0,77575 * \left[ \frac{\mathbf{S}^* g^* (\mathbf{r}_l - \mathbf{r}_g)}{\mathbf{r}_l^2} \right]^{0,25}}{\dot{m}} \right)^{-1}$$

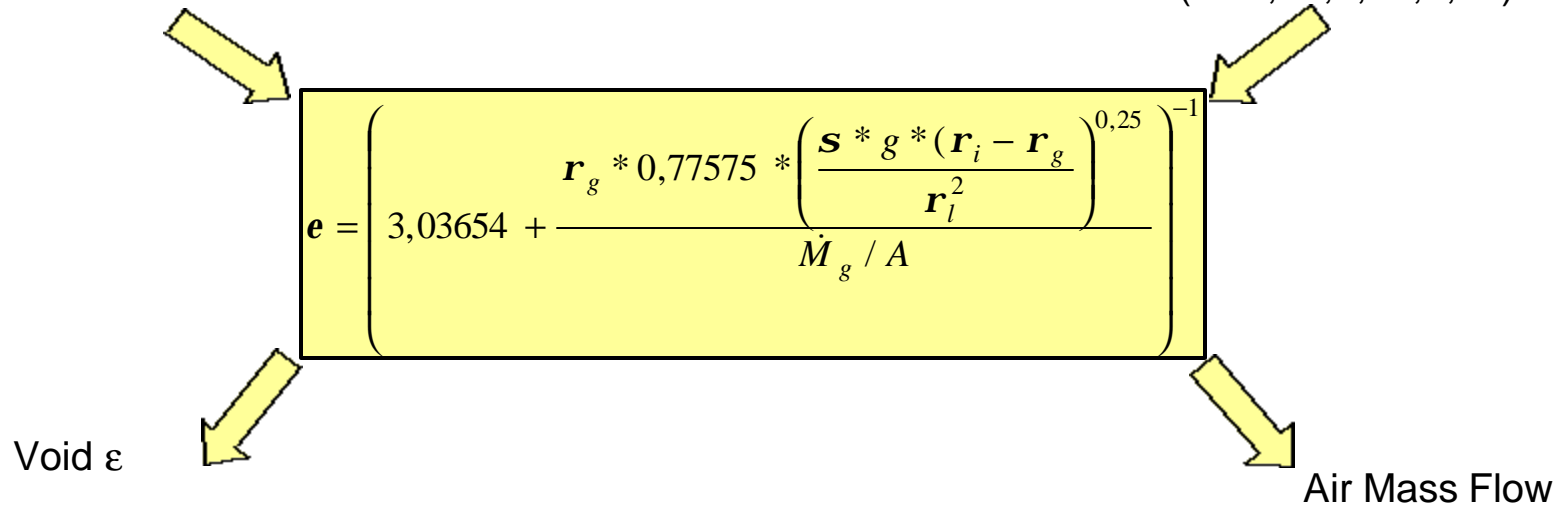
# Mass Flows for the Tests with the Global Model

## SWR 1000, Original

- Properties of Water/Steam (P =2-5 bar)
- Mass flux (P =2-5 bar, Q =4,5;9;13,5 MW)

## SWR 1000, Model

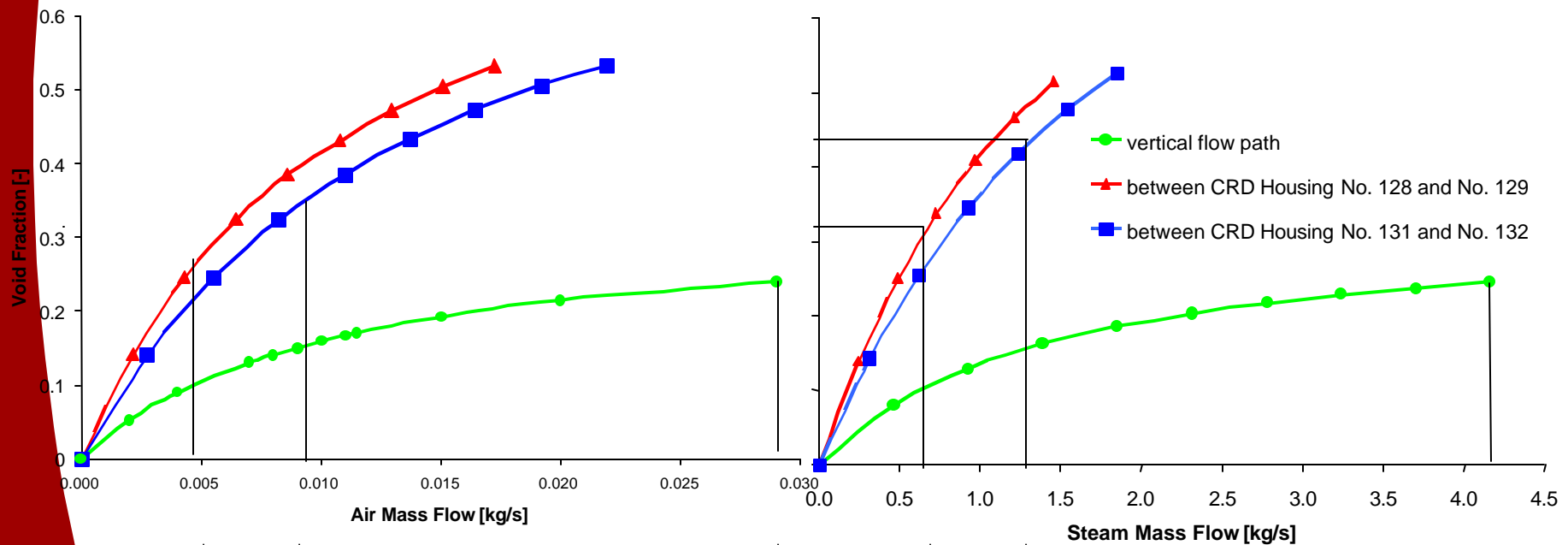
- Properties of Water/Air (P=1 bar)
- Void ( $\epsilon = 0,16; 0,24; 0,28$ )



Q \ P	2 [bar]	3 [bar]	4 [bar]	5 [bar]
4.5 [MW]	0.2224	0.1956	0.1777	<b>0.1598</b>
9 [MW]	0.2655	<b>0.2454</b>	0.2309	0.2152
13,5 [MW]	<b>0.2839</b>	0.2682	0.2564	0.2433

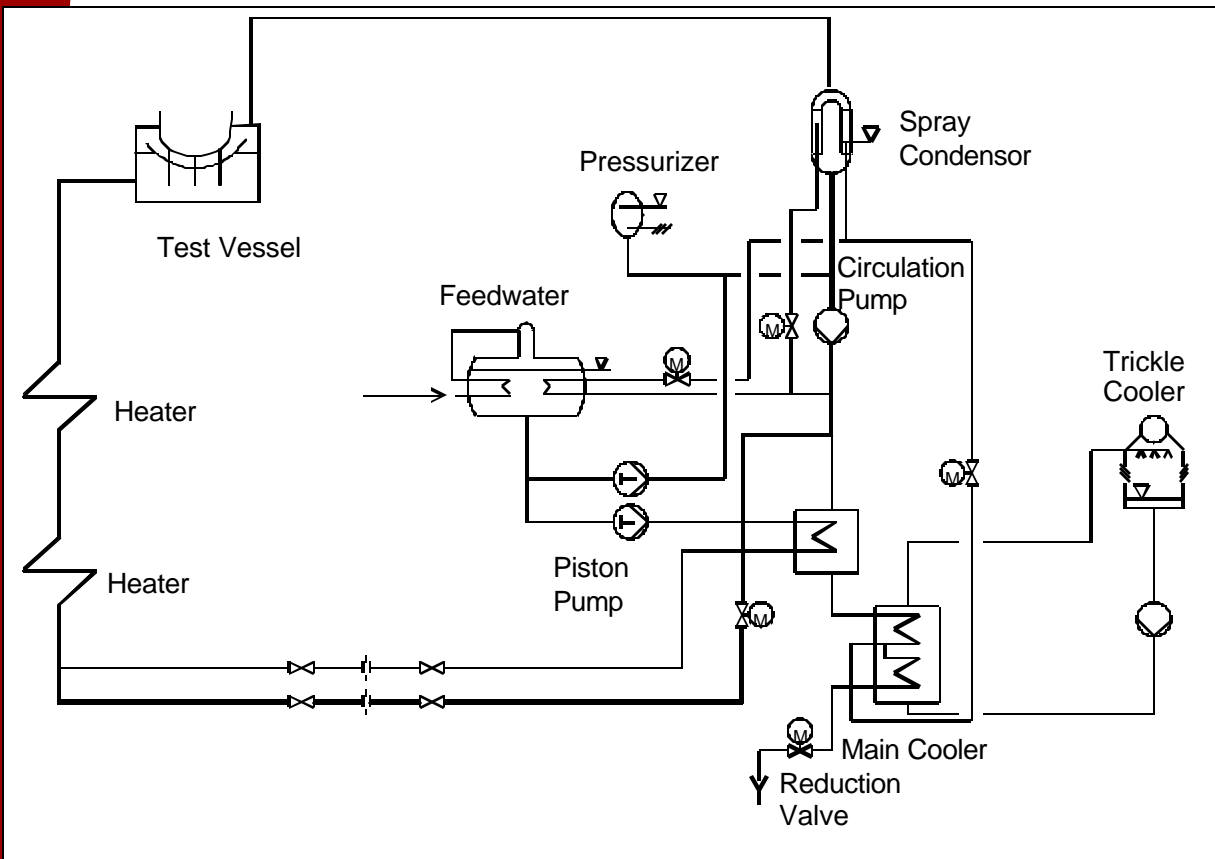
Void $\epsilon$	M [kg/s]
0.16	<b>0.010</b>
0.24	<b>0.029</b>
0.28	<b>0.061</b>

## Comparison of Void Trends - Model (Air 1 bar) and „Original“ (Steam 3 bar)



Corresponding mass flows according mass sources  
(injection / evaporation) for the 100% decay heat case

# Measurement of Safety Margins



Aim of the experiments:

Measurement of the Critical Heat Flux above decay heat

Procedure:

- Implementation of a 1:1 scaled segment in the BVS by considering the in- and outflow conditions evaluated from the water / air - experiments
- Instrumentation of the RPV-wall with thermocouples in order to identify the location of the boiling crisis (CHF)
- Adjusting the mass flow in such a way that the feed water mass flow is equal to the evaporated
- Increasing the heat input stepwise until a boiling crisis-occurred or a relevant safety margin is reached.

# Conclusions and Consequences

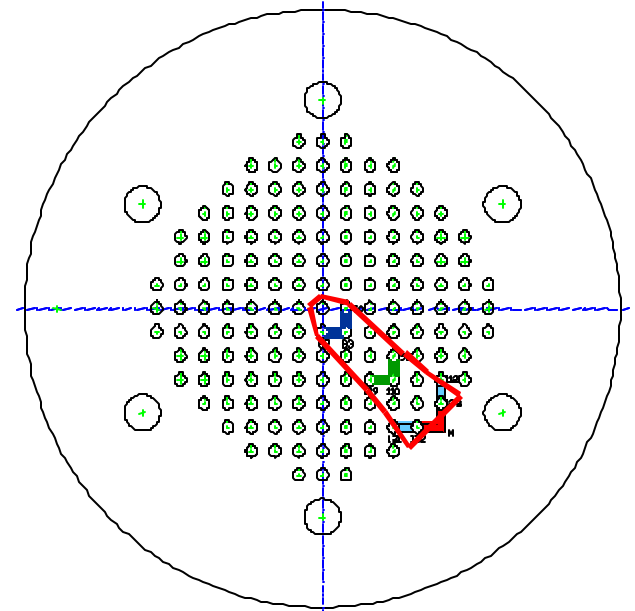
- The natural circulation inside the gap between the insulation and RPV is very strong - compared to the water supply of the external circulation. Thus, it is necessary to simulate the internal circulation in a water steam experiment.
- The flow experiments indicate almost rotational symmetric flow conditions.

The effect of flow and heating conditions is unknown, which might be influenced by the flow orientation from the centre position:

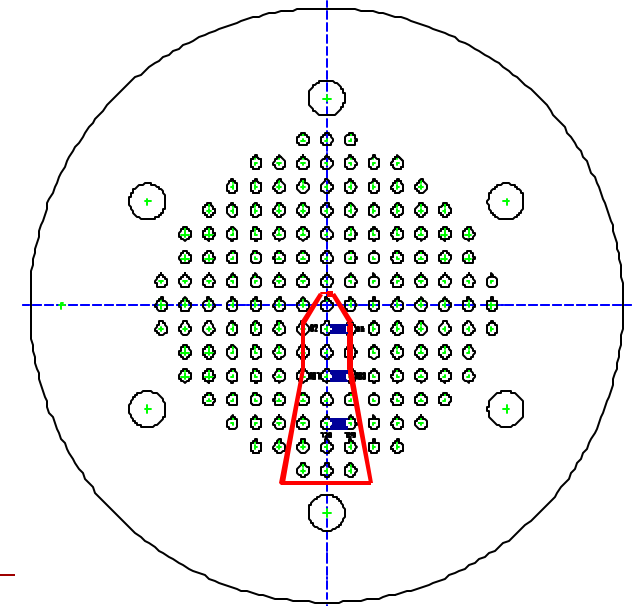
- The effect of a straight-line configuration will be lower flow resistance - compared to a non-straight-line configuration - and herewith a higher mass flows in this area.
- The effect of a non-straight-line configuration will be a better heat transfer behaviour - compared to a straight line configuration.

Conclusion: There will be no significant cross flow between the different orientations if the flow conditions are almost similar for both extreme configurations. In this case it is conservative to use the straight line configuration for a heatable test section.

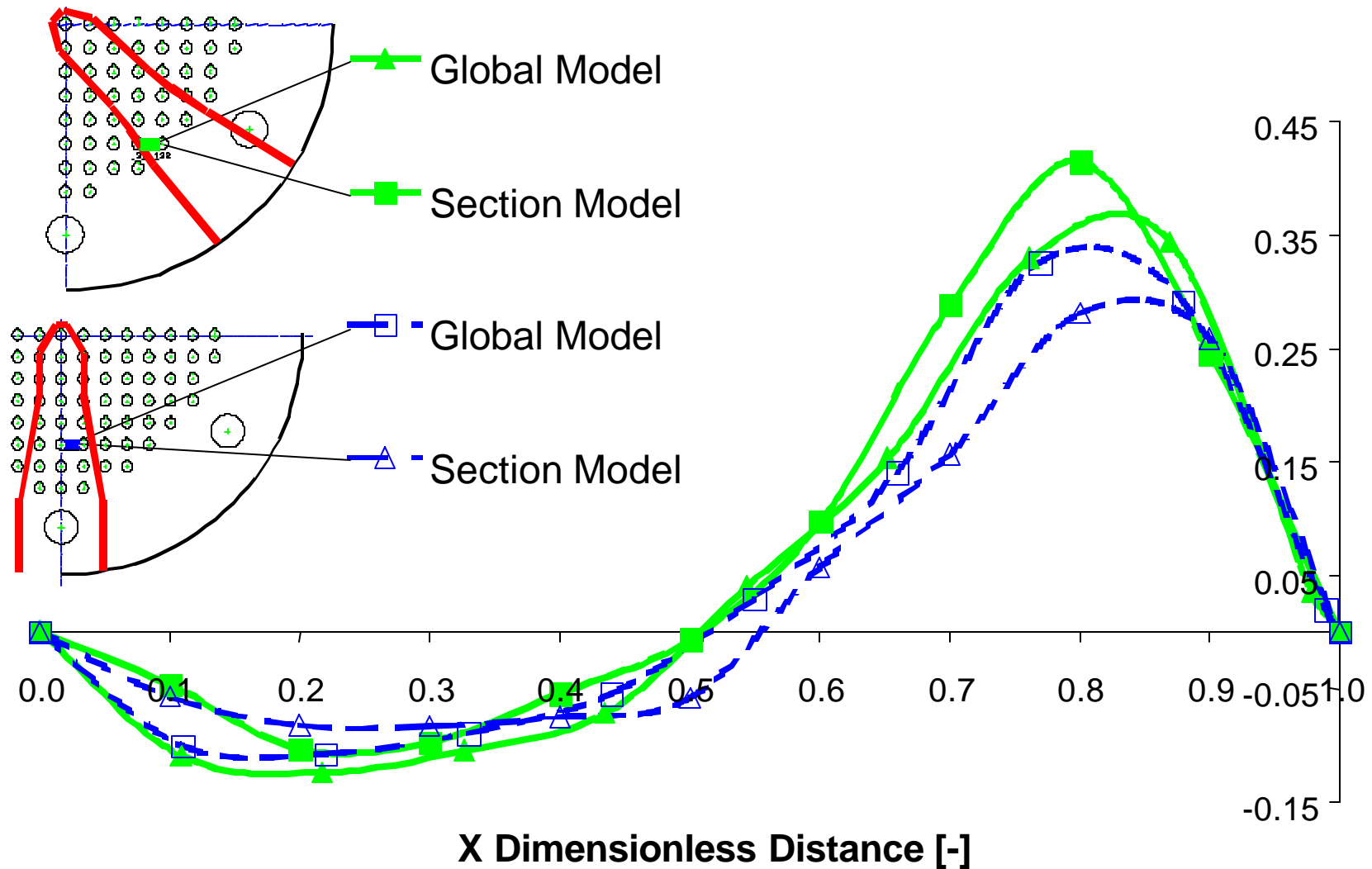
**Non-Straight-Line Configuration**



**Straight-Line Configuration**

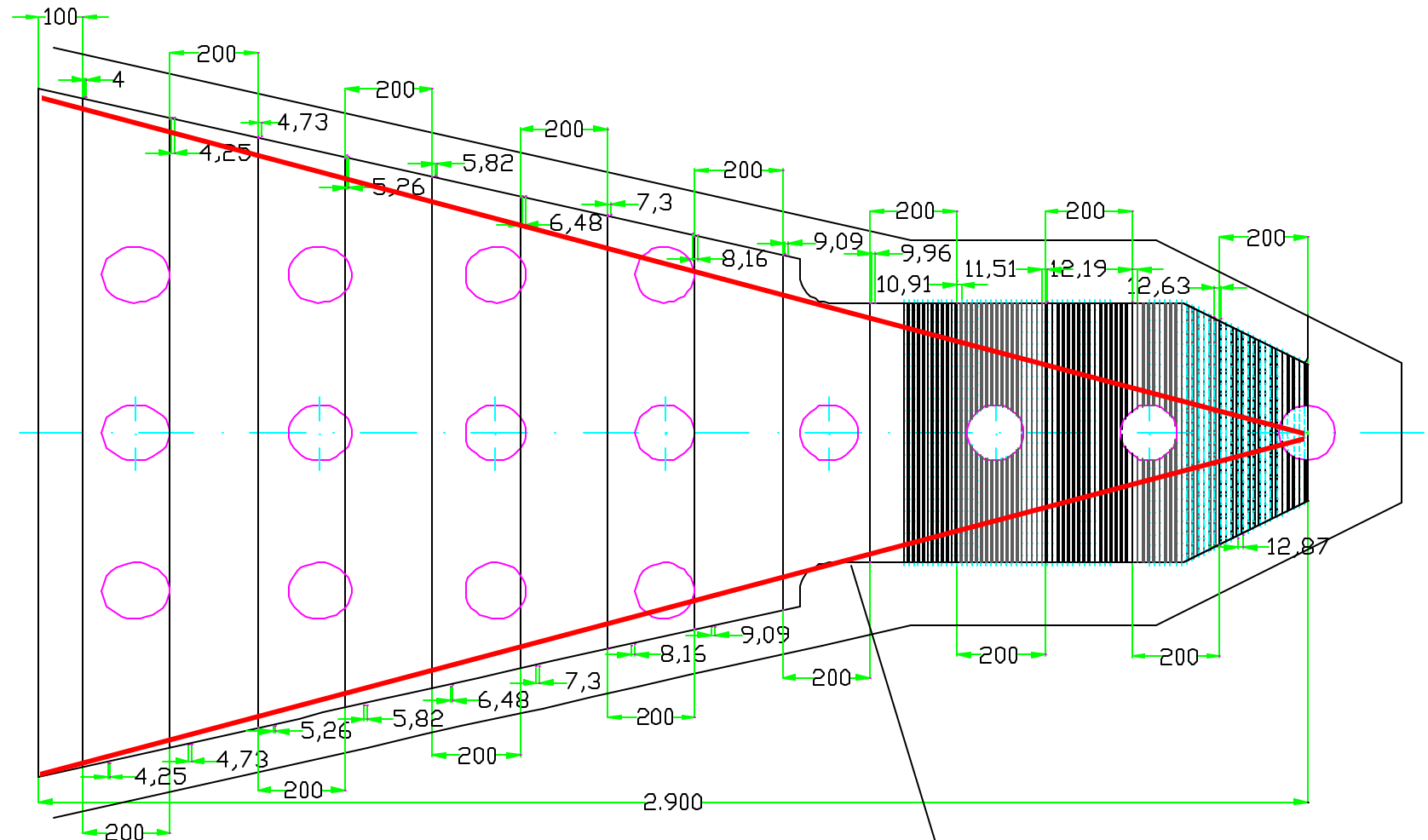


# Global and Section Model Measurements



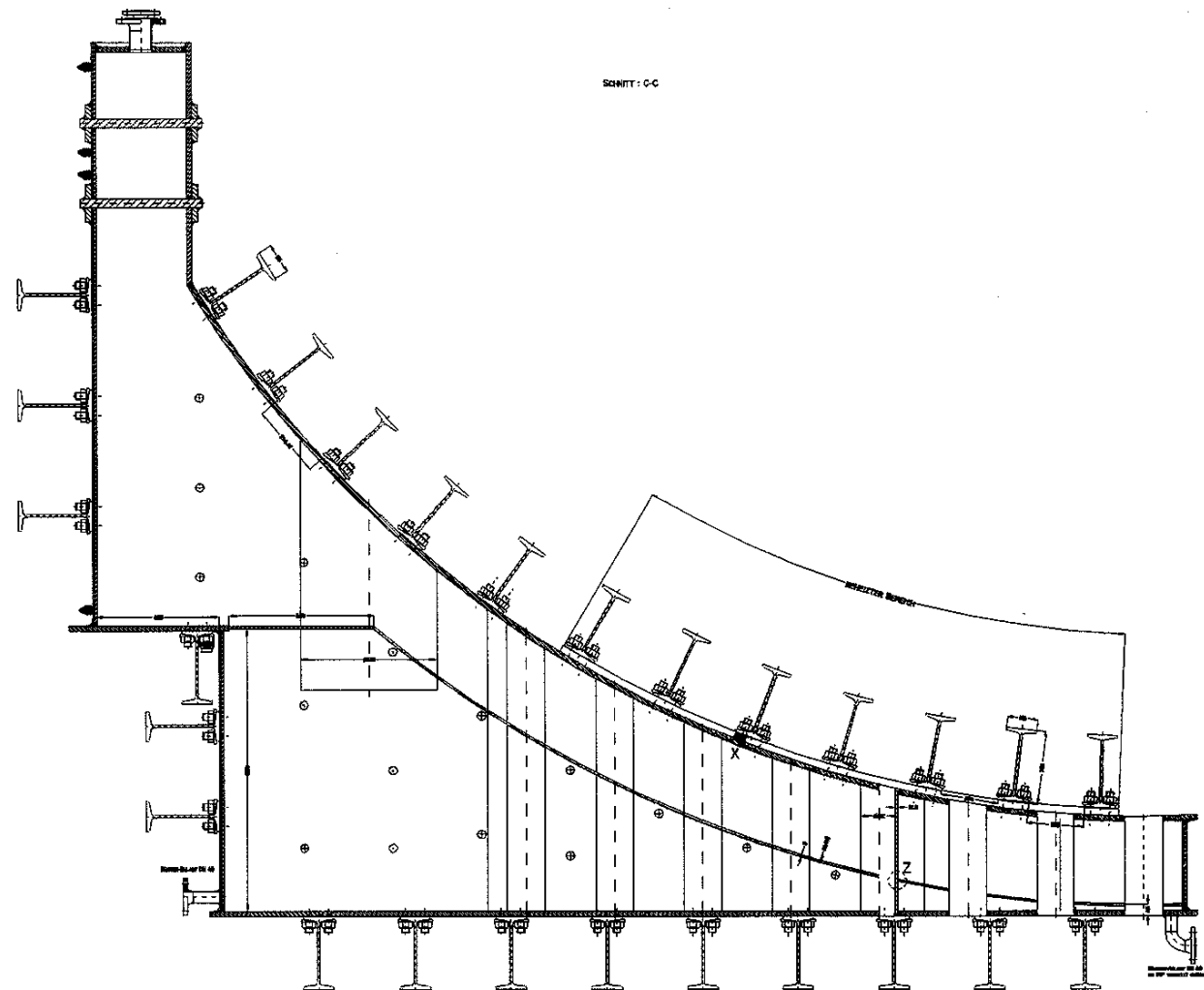


# Heatable Section Model - Top View

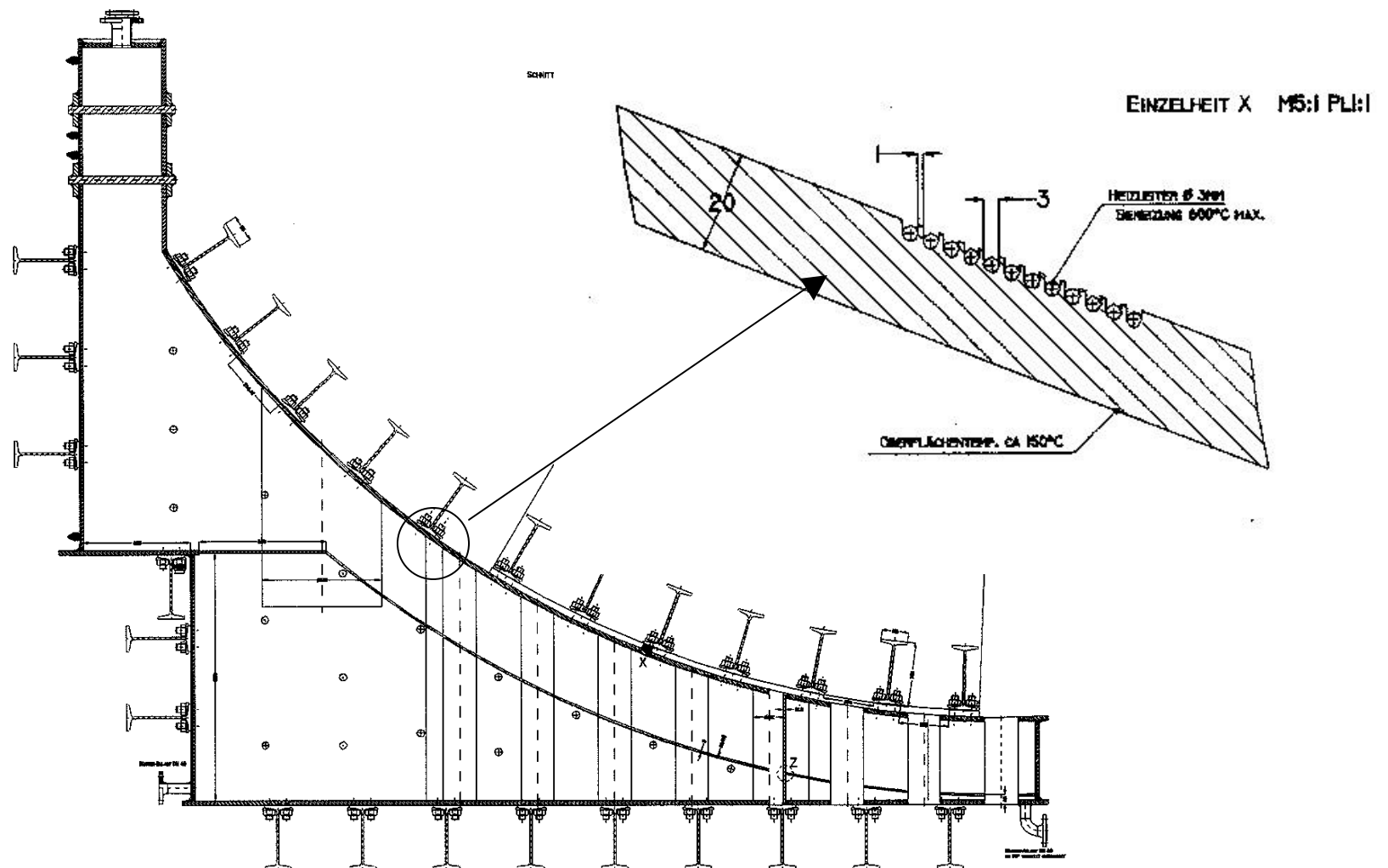


Borders  
of a comparable section

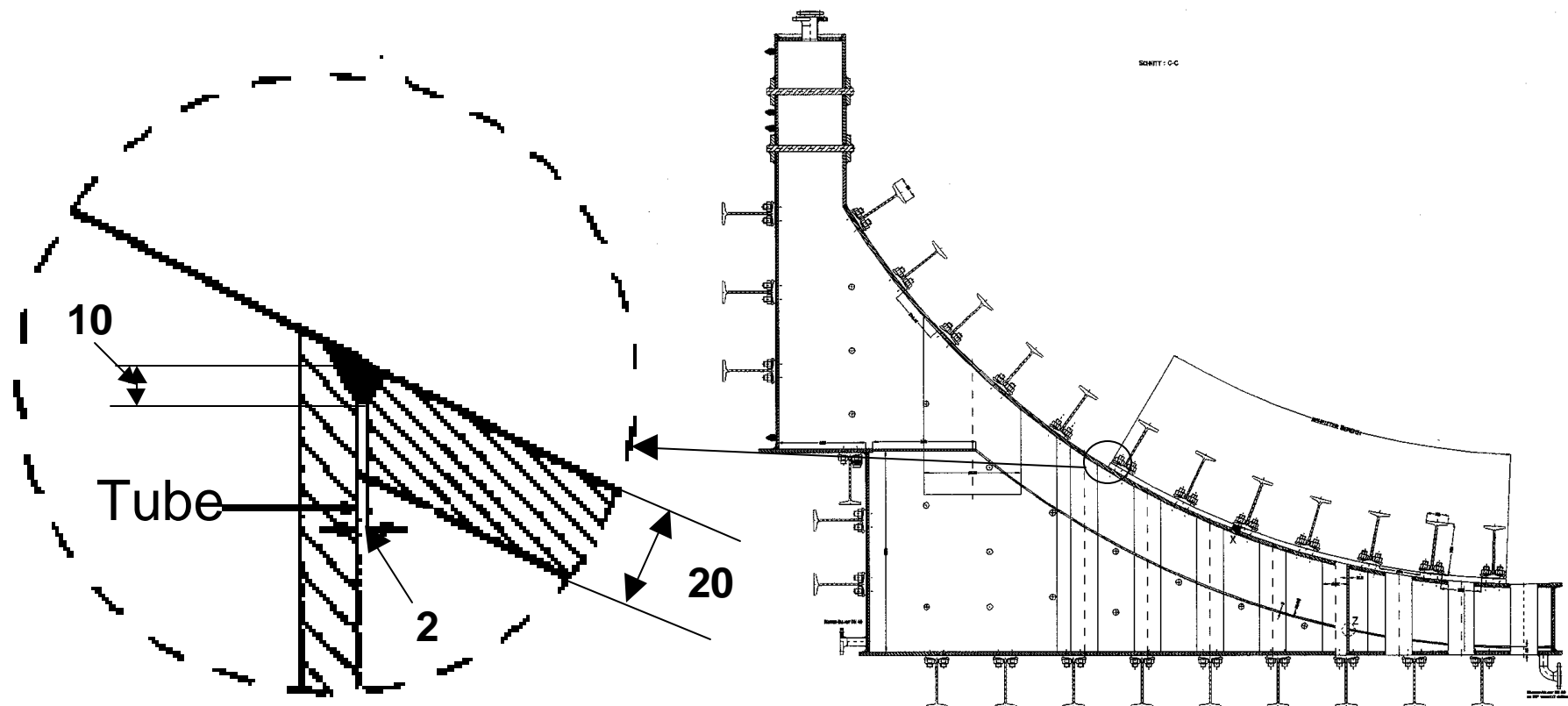
# Heatable Section Model - Side View



# Heatable Section Model - Heating Concept



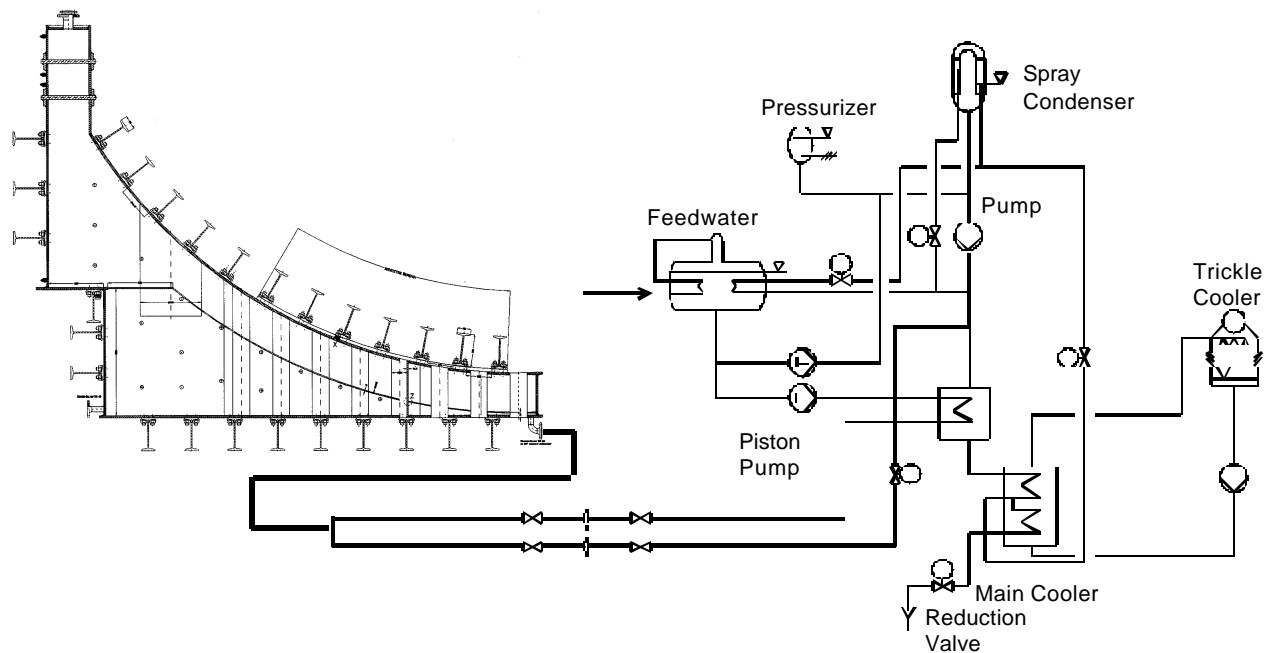
# Heatable Section Model - CRD Housing connection



# External Vessel Cooling Test

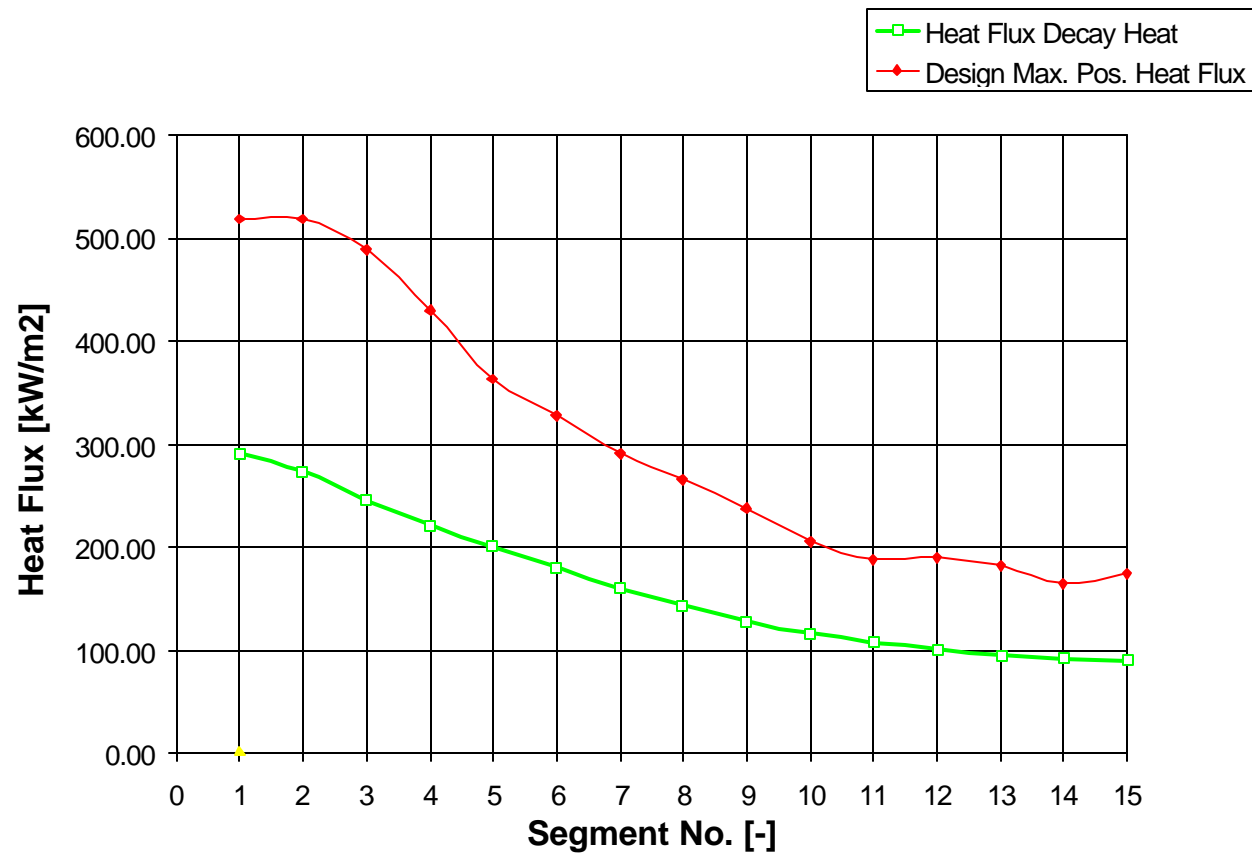
## - Test Objective

*Identification of the safety margins of the exterior cooling concept of the RPV, taking into consideration the influence of the control rod drive housings*



# External Vessel Cooling Test

## - Manufacturing, Heating Wires (1)





# External Vessel Cooling Test

## - Manufacturing, Heating Wires (2)

Heizleiter-Belegungsplan SWR 1000

Nut (Nr.)	Nut im Segment	Länge 1 (mm)	Länge 2 (mm)	Länge 3 (mm)	Länge 4 (mm)	Rolle (-)	HL-Strang (-)
41	15	332	240	237	322	5	10
42	16	325	233	230	320	2	11
43	17	324	228	226	319	2	11
44	18	321	224	222	315	2	11
45	19	316	223	217	312	2	11
46	20	315	219	216	310	2	11
47	21	312	216	212	307	4	12
48	22	309	213	211	306	4	12
49	23	307	211	210	302	4	12
50	24	306	210	208	301	4	12
51	25	305	210	207	300	4	12
52	26	303	210	207	300	4	12
53	27	302	210	206	298	6	13
54	28	299	207	206	296	6	13
55	29	299	209	206	294	6	13
56	30	299	209	207	293	6	13
57	31	298	210	207	292	6	13
58	32	298	209	210	296	6	13
59	33	298	210	210	296	7	14
60	34	298	212	212	296	7	14
61	35	296	215	215	296	7	14
62	36	296	219	216	294	7	14
63	37	297	220	218	294	7	14
64	38	296	222	222	295	7	14
65	39	298	225	226	297	2	15
66	40	299	230	232	297	2	15
67	41	300	235	236	297	2	15
68	42	303	242	240	300	2	15
69	43	305	246	246	301	2	15
70	44	306	257	256	306	3	16
71	45	308	263	265	307	3	16
72	46	315	275	274	309	3	16
73	47	323	287	282	315	3	16
74	1	323	296	310	321	3	16
75	2	334	317	320	335	9	17
76	3	1432	0	0	0	2	17
77	4	1430	0	0	0	2	17
78	5	1427	0	0	0	2	17
79	6	1429	0	0	0	2	18
80	7	1422	0	0	0	2	18

Spezifiziert von: *[Signature]*  
Installiert von: *[Signature]*

Heizleiter-Belegungsplan SWR 1000

Erstellt von: Herbet Oliver, TGT1

Seite 1 von 10

Nut (Nr.)	Nut im Segment	Länge 1 (mm)	Länge 2 (mm)	Länge 3 (mm)	Länge 4 (mm)	Rolle (-)	HL-Strang (-)	linke Seite	Art der Anschlüsse	rechte Seite	Bögen	Anschlüsse	Verbinden	Abnahmemessung Strom [A] Spannung [V] Widerstand [Ohm]	Farb- legende
1	1	1567	0	0	0	4	1	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
2	2	1565	0	0	0	4	1	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	1
3	3	1564	0	0	0	4	1	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
4	4	1561	0	0	0	4	1	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	2
5	5	1559	0	0	0	4	2	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
6	6	1557	0	0	0	4	2	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	3
7	7	1555	0	0	0	4	2	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
8	8	1554	0	0	0	4	2	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	4
9	9	1554	0	0	0	4	3	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
10	10	1553	0	0	0	4	3	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	5
11	11	1550	0	0	0	4	3	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
12	12	1547	0	0	0	4	3	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	6
13	13	1545	0	0	0	4	4	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
14	14	1545	0	0	0	4	4	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	7
15	15	1545	0	0	0	4	4	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
16	16	1544	0	0	0	4	4	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	8
17	17	1542	0	0	0	4	5	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
18	18	1540	0	0	0	4	5	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	9
19	19	1537	0	0	0	4	5	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
20	20	1535	0	0	0	4	5	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	10
21	21	1533	0	0	0	4	6	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
22	22	1531	0	0	0	4	6	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	11
23	23	1530	0	0	0	4	6	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
24	24	1529	0	0	0	4	6	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	12
25	25	1525	0	0	0	4	7	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
26	26	1525	0	0	0	4	7	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	13
27	1	1522	0	0	0	4	7	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
28	2	1520	0	0	0	4	7	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	14
29	3	1519	0	0	0	6	8	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
30	4	1518	0	0	0	6	8	Bogen aus 3mm Kupfer	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	15
31	5	1516	0	0	0	6	8	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
32	6	1514	0	0	0	6	8	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1			4.3 36 8.4	16
33	7	1512	0	0	0	2	9	Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.3 36 8.4	Rolle
34	8	372	318	211	367	2	9	Bogen aus 3mm Kupfer	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1		3	4.8 36 7.5	17
35	9	364	296	292	357	2	9	Anschluß Kupferschleife "s"	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1	1	3	4.3 36 8.4	Rolle
36	10	364	284	275	351	2	9	Anschluß Kupferschleife "s"	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1		3	4.3 36 8.4	18
37	11	346	272	265	346	5	10	Anschluß Kupferschleife "s"	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1	1	3	4.3 36 8.4	Rolle
38	12	340	262	256	340	5	10	Bogen aus 3mm Kupfer	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1		3	4.3 36 8.4	19
39	13	337	252	249	333	5	10	Anschluß Kupferschleife "s"	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1		3	4.3 36 8.4	20
40	14	335	245	243	325	5	10	Bogen aus 3mm Kupfer	3X Kupferverbinder 3mm	Bogen aus 3mm Kupfer	1		3	4.3 36 8.4	21

Spezifiziert von: *[Signature]*  
Installiert von: *[Signature]*

Geprüft von: *[Signature]*  
11.10.02

Tab.-Nr.: NT31-00-918167/T1  
Datum: 11.07.2002

Anschluß Kupferschleife "s"	-	Bogen aus 3mm Kupfer	1	1		4.7	36	7.7	7
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Geprüft von: *[Signature]*  
11.10.02

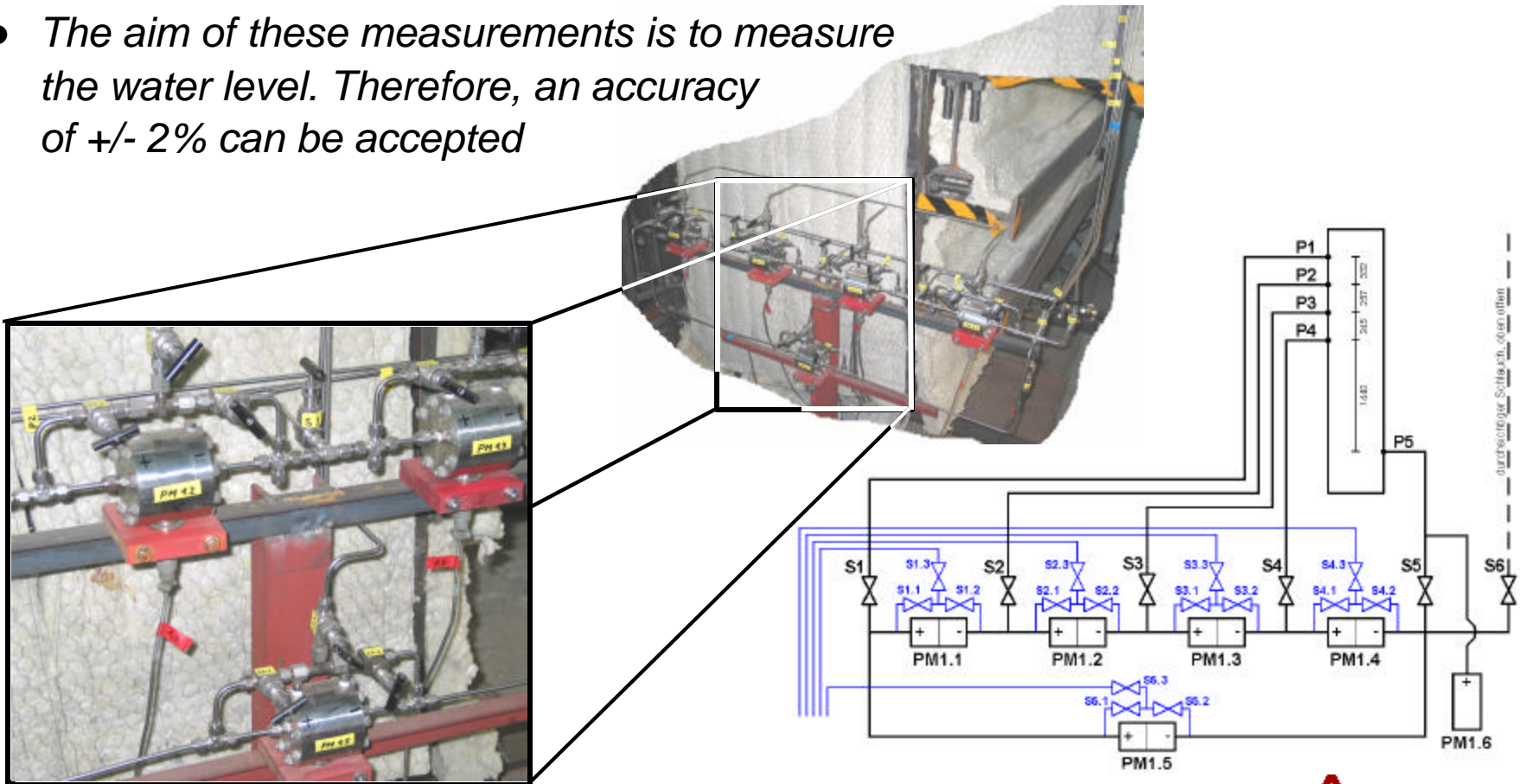
Tab.-Nr.: NT31-00-918167/T1  
Datum: 11.07.2002

# External Vessel Cooling Test

## - Measuring Equipment, Pressure/Level

*Pressure differences shall be measured at three different levels*

- *Each of the pressure and pressure drop sensors has to be checked against a calibrated pressure checking device or a water column*
- *The aim of these measurements is to measure the water level. Therefore, an accuracy of +/- 2% can be accepted*

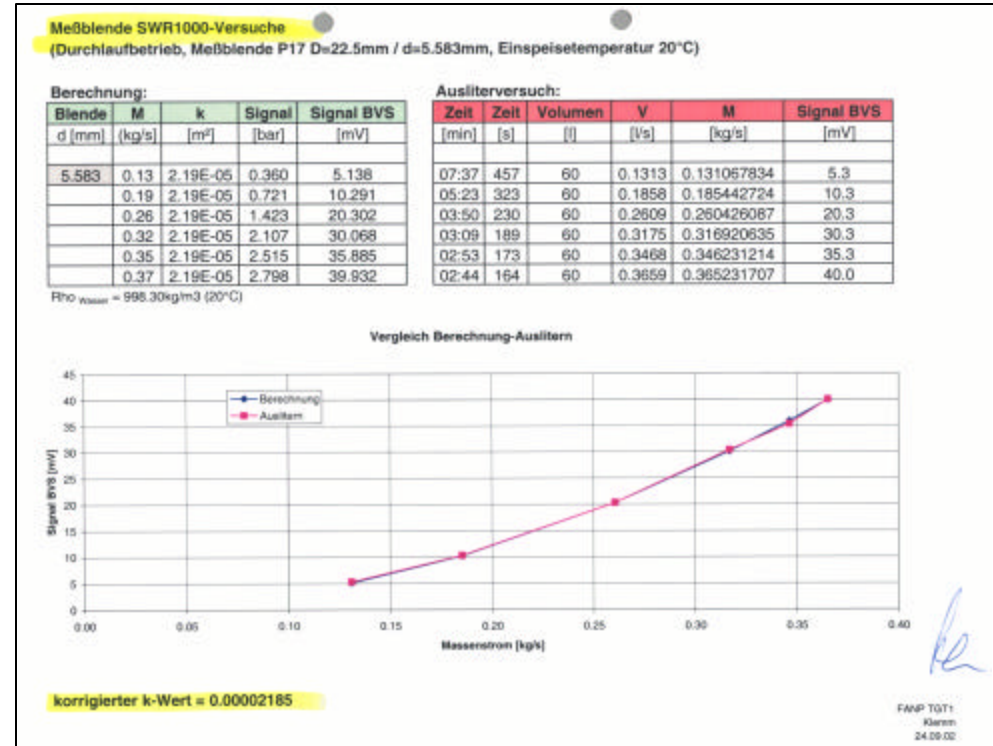


# External Vessel Cooling Test

## - Measuring Equipment, Mass Flow

*The inlet mass flow will be measured via an orifice. This measurement will be checked via the measurement of the time to fill a defined volume of 60 liters*

- *The orifice should be chosen in a way that a mass flow could be measured from 0.4 to 0.0025kg/s at 104°C*
- *The aim of these measurements is to check, whether the test object will be supplied with almost constant flow conditions. Therefore, an accuracy of +/- 4% can be accepted*

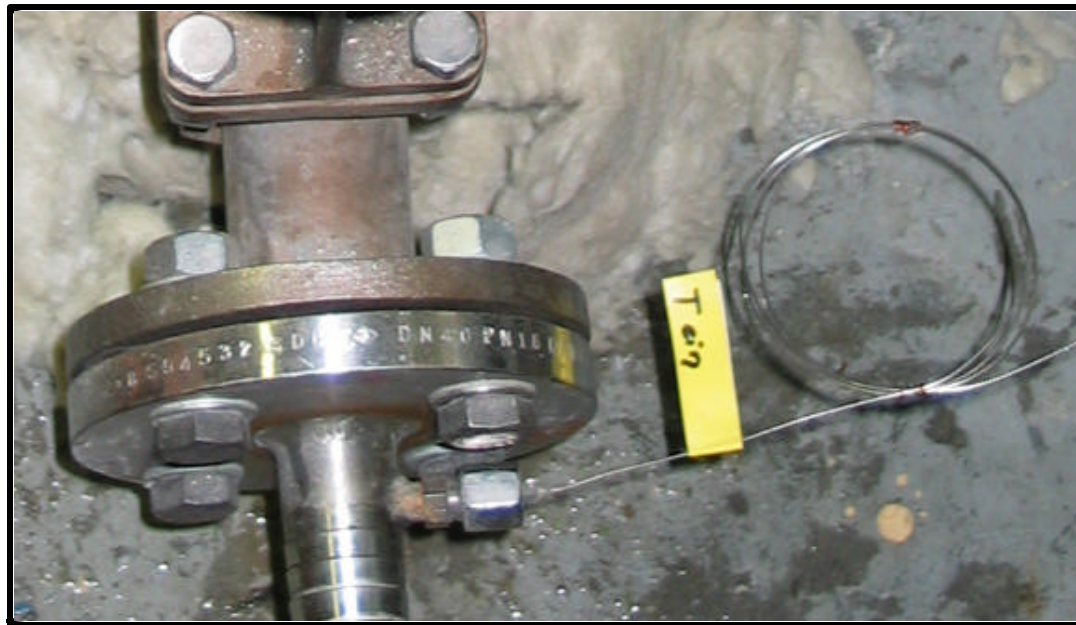




# External Vessel Cooling Test

## - Measuring Equipment, Inlet Temperature

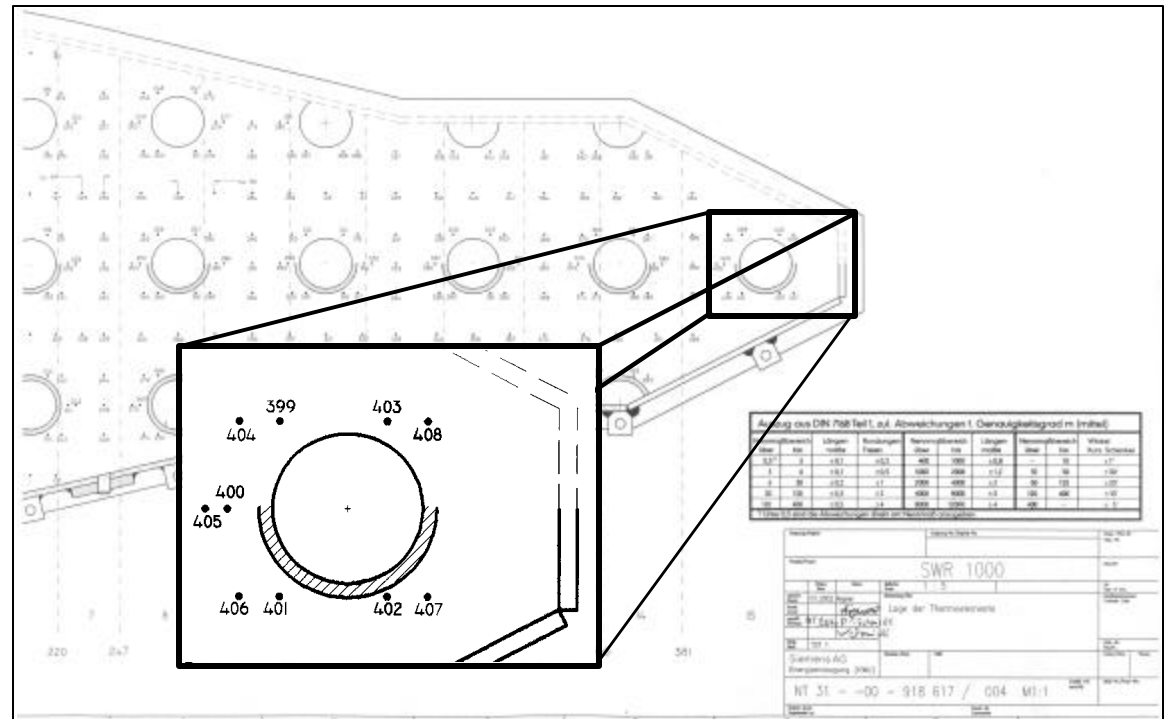
*The inlet temperature measurement will be checked via measuring the boiling temperature at ambient conditions. An accuracy of  $\pm 2\text{K}$  can be accepted*



# External Vessel Cooling Test

## - Measuring Equipment, Heated Surface (1)

- > *The temperature measurements of the heated surface will be checked based on plausibility*
  - *Plausibility check is described in the Test Procedure (FANP TGT1/02/e42)*
  - *Installation has to be done and checked according to the respective drawing*



# External Vessel Cooling Test

## - Measuring Equipment, Heated Surface (2)

Belegungsplan SCXI 1303 - Module

Chassis	Slot	Kanal auf Platine	Thermoelement-Nr.	Kanal - Nr. in Meßstellenliste
1	3	0	RWT 001	0
1	3	1	RWT 002	1
1	3	2	RWT 003	2
1	3	3	RWT 004	3
1	3	4	RWT 005	4
1	3	5	RWT 006	5
1	3	6	RWT 007	6
1	3	7	RWT 008	7
1	3	8	RWT 009	8
1	3	9	RWT 010	9
1	3	10	RWT 011	10
1	3	11	RWT 012	11
1	3	12	RWT 013	12
1	3	13	RWT 014	13
1	3	14	RWT 015	14
1	3	15	RWT 016	15
1	3	16	RWT 017	16
1	3	17	RWT 018	17
1	3	18	RWT 019	18
1	3	19	RWT 020	19
1	3	20	frei	frei
1	3	21	RWT 022	21
1	3	22	RWT 023	22
1	3	23	RWT 024	23
1	3	24	RWT 025	24
1	3	25	RWT 026	25
1	3	26	RWT 027	26
1	3	27	frei	frei
1	3	28	RWT 029	28
1	3	29	RWT 030	29
1	3	30	frei	frei
1	3	31	Vergleichsstelle	31

Chassis	Slot	Kanal auf Platine	Thermoelement-Nr.	Kanal - Nr. in Meßstellenliste
1	4	0	RWT 032	32
1	4	1	RWT 033	33
1	4	2	frei	frei
1	4	3	RWT 035	35
1	4	4	RWT 036	36
1	4	5	RWT 037	37
1	4	6	RWT 038	38
1	4	7	RWT 039	39
1	4	8	RWT 040	40
1	4	9	RWT 041	41
1	4	10	RWT 042	42
1	4	11	RWT 043	43
1	4	12	RWT 044	44
1	4	13	RWT 045	45
1	4	14	RWT 046	46
1	4	15	frei	frei
1	4	16	RWT 048	48
1	4	17	RWT 049	49
1	4	18	RWT 050	50
1	4	19	RWT 051	51
1	4	20	frei	frei
1	4	21	RWT 053	53
1	4	22	frei	frei
1	4	23	RWT 055	55
1	4	24	RWT 056	56
1	4	25	RWT 057	57
1	4	26	RWT 058	58
1	4	27	RWT 059	59
1	4	28	frei	frei
1	4	29	frei	frei
1	4	30	RWT 062	62
1	4	31	Vergleichsstelle	63

Meßstellenliste:

MST	KAN	STF	Bezeichnung	Kurz-bezeichnung	Meß-wandler	Meßbereich	SI-Meßbereich	Meßort	Bemerkung
1	0		Temperatur 001	TE RWT001	SCXI-11 02		0 - 1000 °C		SCXI Chassis1 SLO703
2	1		Temperatur 002	TE RWT002	SCXI-11 02		0 - 1000 °C		SCXI Chassis1 SLO703
3	2		Temperatur 003	TE RWT003	SCXI-11 02		0 - 1000 °C		SCXI Chassis1 SLO703
4	3		Temperatur 004	TE RWT004	SCXI-11 02		0 - 1000 °C		SCXI Chassis1 SLO703
5									SCXI Chassis1 SLO703
6									SCXI Chassis1 SLO703
7									SCXI Chassis1 SLO703
8									SCXI Chassis1 SLO703
9									SCXI Chassis1 SLO703
10									SCXI Chassis1 SLO703

Autor: Herbst  
Datei: SWR1000.mst  
Versuchsdatum: 01.11.02



Geprüft  
14.3.03  
[Signature]

FANP TGT1 / Herbst / 3/13/03



Certificate of Calibration

Board Information

Serial Number: 008100  
NI Part Number: 60502E-01  
Manufacture: DAQCard-6050E

Certificate Information

Certificate Number: 149994  
Date: 11 MAY 2002  
NI Part Number: 134632A-01

Calibration Date: 05 MAY 2002  
Calibration Interval: 12 Months  
Calibration Due: 05 MAY 2003

Ambient Temperature: 23 °C  
Relative Humidity: 52 %

National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with the applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9002 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.

National Instruments further certifies that the measurement standards and instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology or are derived from accepted values of natural physical constants.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.

For questions or comments, please contact National Instruments Technical Support.

Signed,

[Signature]

Joseph Brochtrup  
Test Engineering Manager



# External Vessel Cooling Test

## - Measuring Equipment, Power Supply

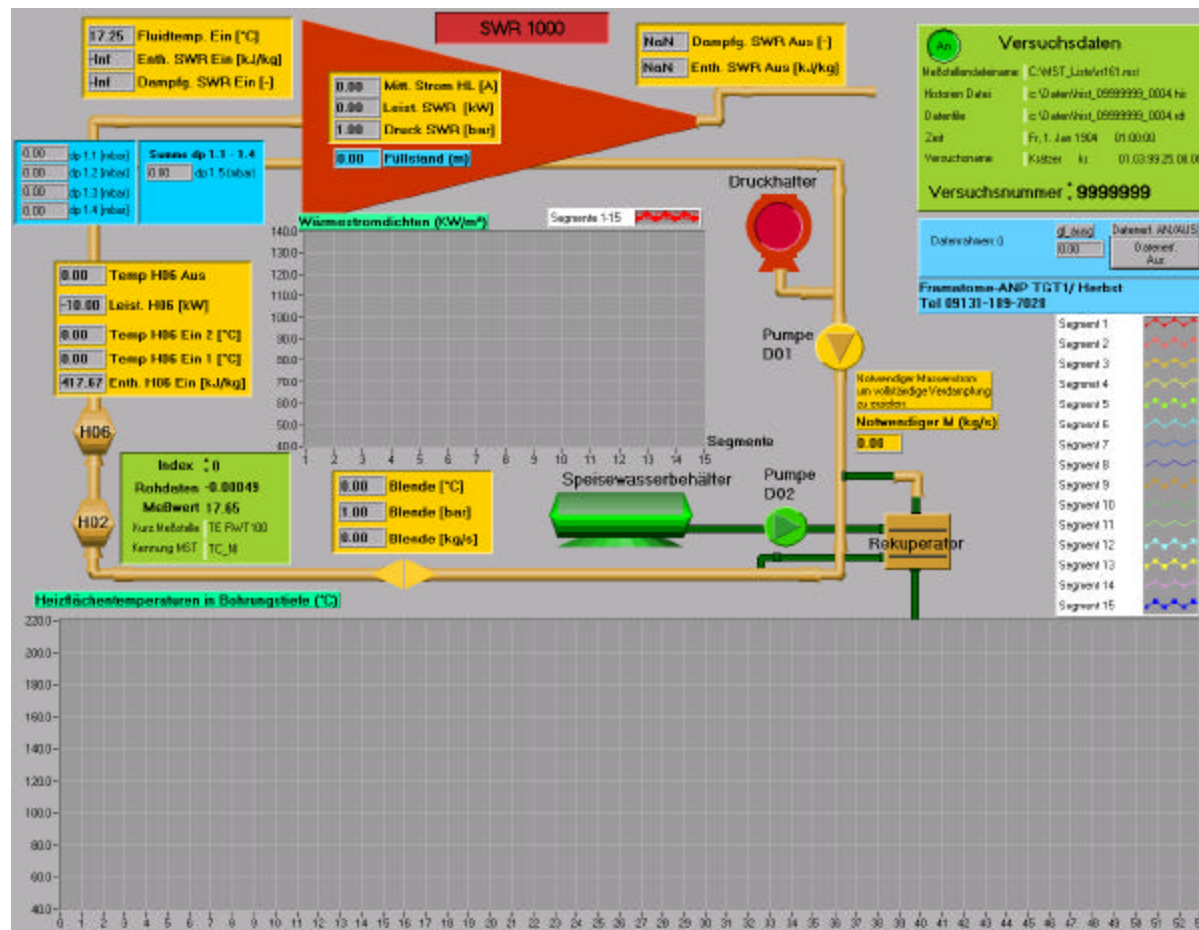
*The measurement of voltage and current supplying the heating wires is part of the BENSON test rig instrumentation.*

- *The functioning of this has been checked during test running in August 2002*
- *Within further tests in the following years this standard instrumentation will be checked regularly again*



# External Vessel Cooling Test Data Acquisition Software (1)

## Online display



# External Vessel Cooling Test - Data Acquisition Software (2)

## "Quicklook"

