Technology MATTERS™

Presentation to USNRC
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CCI Chemical Testing
Status of Strainer Testing

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Contents

- Basic requirements of WCAP-16530-NP
- CCI chemical testing strategy
- Labororatory bench testing by Niutec
- Short description of strainer geometries
- Overview of past and future Chemical Testing

Basic WOG document for chemical tests

- WCAP-16530-NP, Evaluation of Post Accident Chemical Effects in Containment Sump Fluids to Support GSI-191, Rev.0, Feb. 2006
    - Containment Materials
    - Test Plan (Dissolution, Precipitation)
    - Bench Testing (Dissolution, Precipitation)
        - Settling Rates, Sizes, Filterability
    - Chemical Model
    - Particulate generator

Importance of Elements in Solution

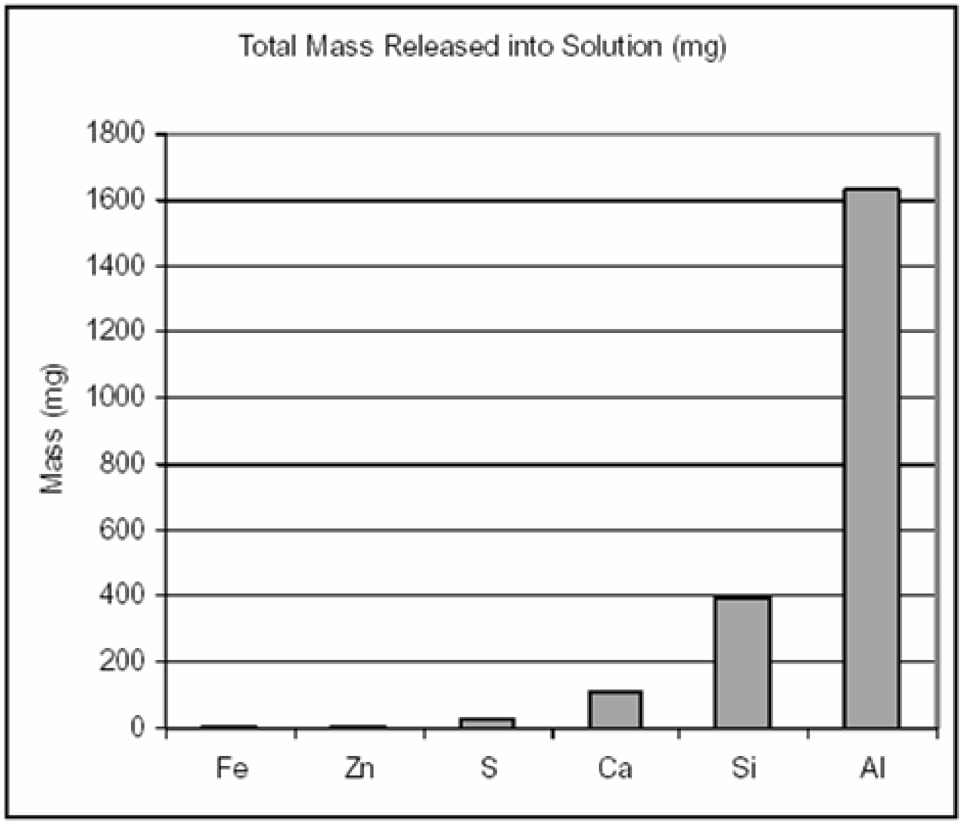
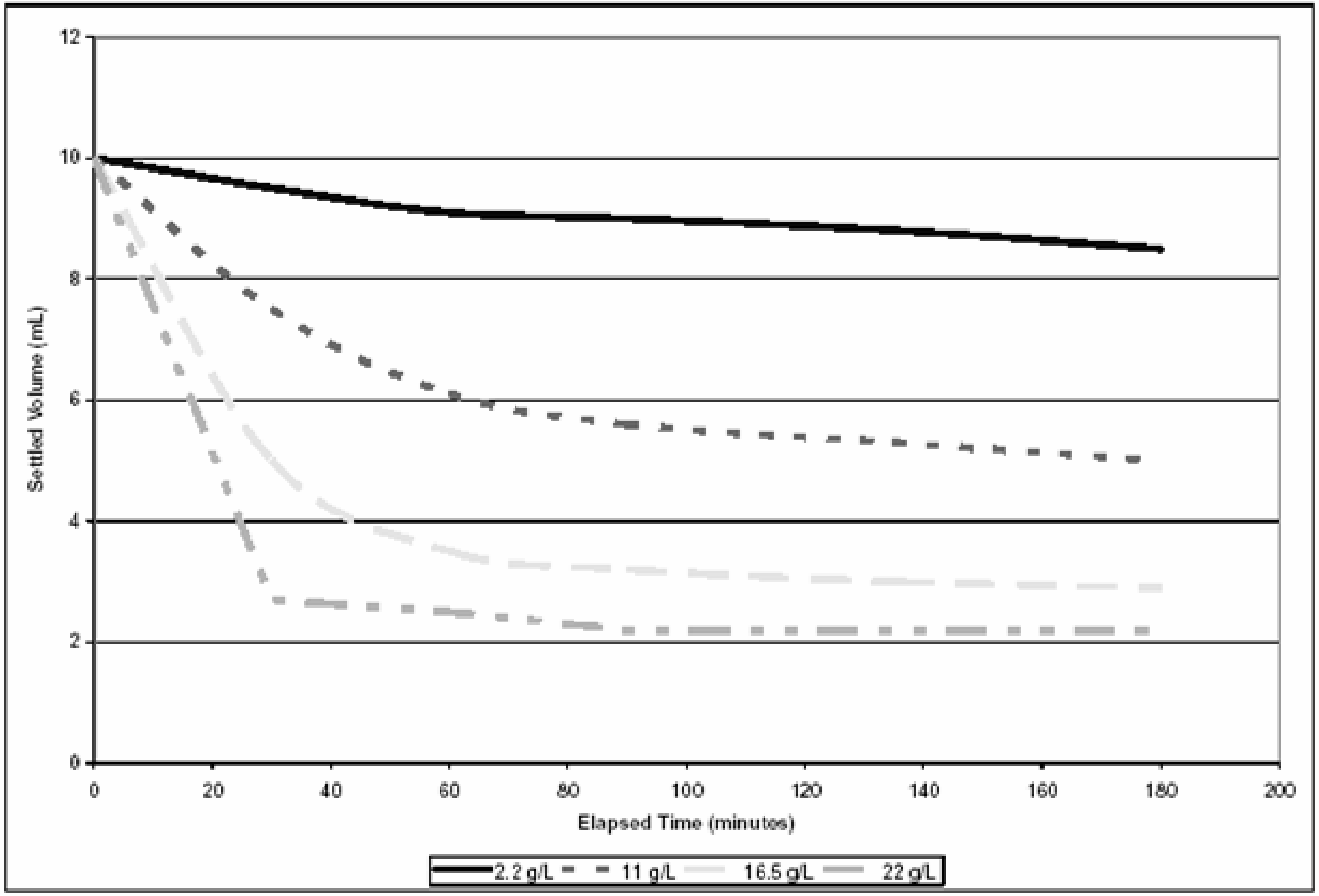


Figure 5.2-10: Comparison of Total Mass Released during Dissolution Testing by Element

Figure 7.6-1: Settling Rate of 2.2 g/L AlOOH as a Function of Mix Tank Concentration



Importance of precipitate concentration in WCAP

7.7 CONCLUSIONS FROM PARTICULATE GENERATOR TESTS

Testing of the particulate generator demonstrated that simulated particulates can be successfully generated for use in sump screen testing. Generation of the particulates is generally straightforward, and can be performed using readily available equipment and materials. The testing confirmed that the quality and temperature of the water used to prepare the particulates, and that used in the screen test loop, is not critical. No special water chemistry control is required to use the generated particulates in screen testing. The most critical parameter determined during the testing was the limitation on the degree of concentration of the particulates in the mixing tank. In the event that large quantities of particulates are required, the particulates may be prepared in batches or in multiple mixing tanks.

Strategy of CCI Chemical Testing

- Use whole (large size) loop as precipitate generator
- Advantages :
  - Precipitate concentration is closest to real plant conditions
  - Minimal Effect of coagulation of precipitates
  - Minimal effect on settling rate
  - No contradiction to WCAP (>20% loop volume for chemical generation)
  - No interferences with components (pumps, pipes etc.) of another separate generator
  - Chemistry is more easily controllable
  - 1 volume or step less is to analyze and verify chemically
  - AND ….DEFENDABLE CONTROL OF WATER LEVEL !!!

Chemical Materials

Test Chemicals	Boric Acid	If applicable: TSP, Borax (Sodium borate)	Sodium Aluminate	Calcium Chloride	Sodium Silicate
Precipitates			Aluminum (Oxy-) hydroxide	Calcium Aluminum Silicate (case dependent Calcium Phosphate)	Sodium Aluminum Silicate
pH control	Lowering pH	Rising pH	Rising pH		Rising pH, pH-adjustment

Laboratory Bench Tests

- Purposes :
  - Determine quality of chemicals (assays)
  - Determine necessary amounts of chemicals for HL test
  - Determine influence of tap water vs deionized water
  - Determine influence of debris types (e.g. stone flour, CalSil)
  - Determine characteristics of precipitates (settling rate, sizes, filterability, viscosity)
  - Compare precipitate properties with WCAP values

Laboratory Bench Tests - Steps

- Chemical Assays (all chemicals and stone flour)
- Solubility of debris(e.g. stone flour) in boric acid
- Mixing Test for whole simulation (deionized water)
- Mixing Test for whole simulation (tap water)
- Mixing Test with stone flour (deionized water)
- Mixing Test with stone flour (tap water)

Laboratory Bench Tests – Steps (Continued)

- Determination of Total Suspended Solids (TSS)
- Determination of Boron, Sodium, Calcium and Aluminum
- Determination of Silicate, Phosphate
- Determination of pH
- Determination of Viscosity, Settling Rate (i.e. 1-hour settling volume), Size and Filterability

CCI overall testing experience

Type of Test Loop	Small	Large	MultiPurpose
Number of pockets (typically)	6	120	40
Flow rate capacity (gpm, approx.)	440	440	880
Experience in total test days for USA plants	30	80	190
Experience in chemical testing (from above)	10	5	65

ICET Test Program at Los Alamos

Buffer Agent	100% Fiberglass	80% CalSil 20% Fiberglass
Sodium Hydroxide	Test 1	Test 4
Trisodium Phosphate	Test 2	Test 3
Sodium Tetraborate	Test 5	

Overview of done Chemical testing

- Plant 1
  - NaOH buffer, ICET # 1 chemistry
- Plant 2
  - NaOH buffer, ICET # 1 chemistry
- Plant 3
  - NaOH buffer, ICET # 4 chemistry
- Plant 4
  - TSP buffer, ICET # 2 chemistry
- Plant 5
  - TSP buffer, ICET # 2 chemistry

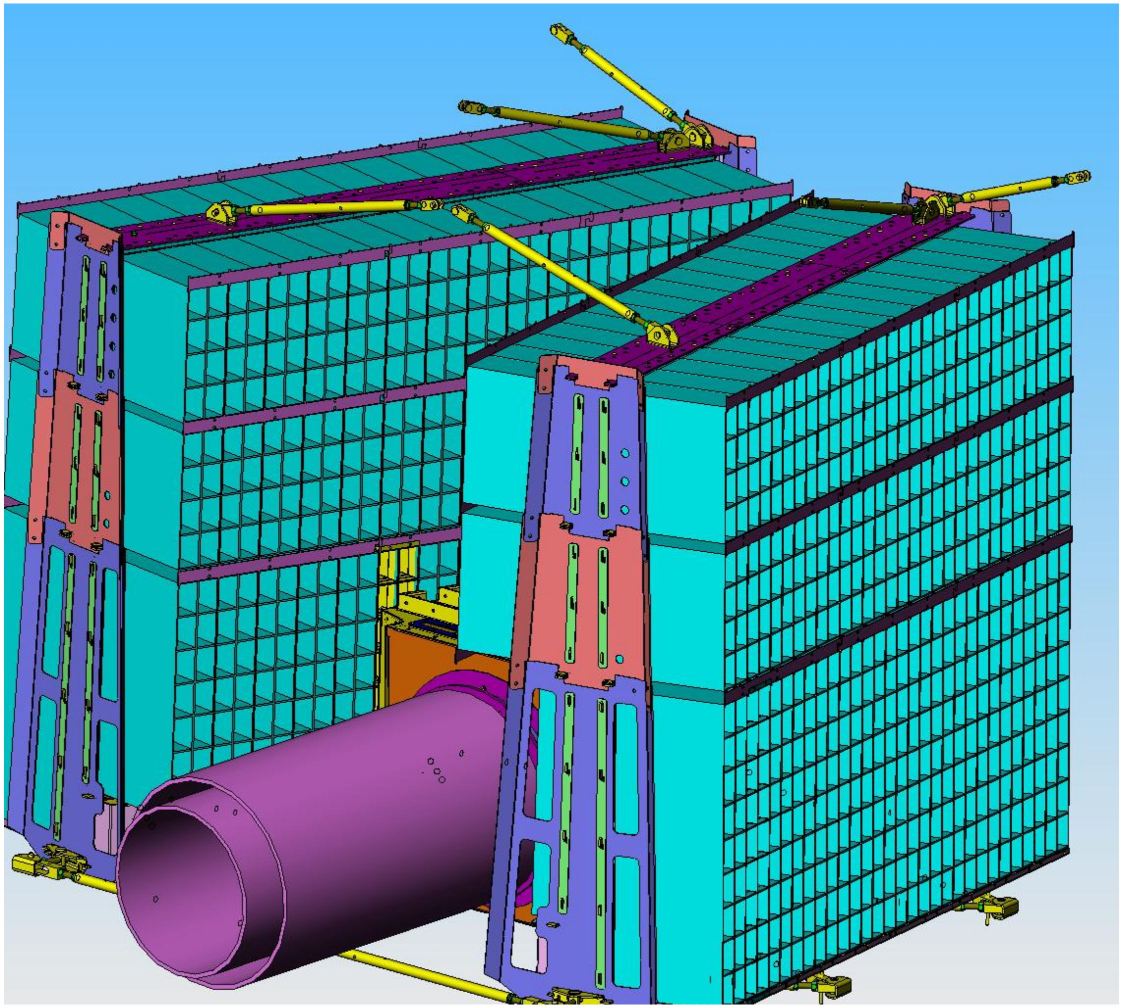
Comparison of test data

Plant	Test screen (m2)	Test Flow rate (m3/h)	Screen Penetration Velocity (mm/s)	Approach Velocity (mm/s)
Plant 1	5.0	64.22	3.57	44.4
Plant 2	2.49	13.18/7.48	1.47/0.83	18.3/10.3
Plant 3	5.0	48.95	2.71	33.7
Plant 4	4.5	46.33	2.86	35.6
Plant 5	4.1	16.54	1.12	13.9

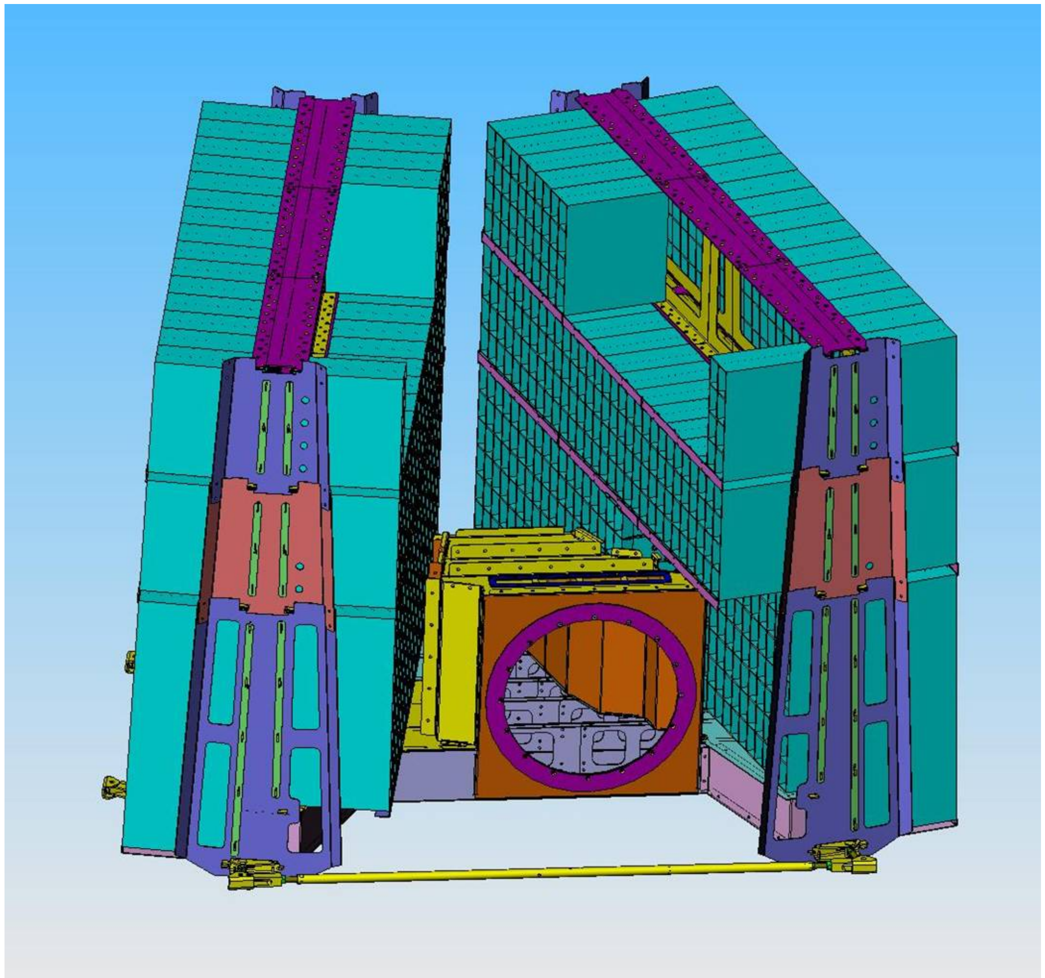
Comparison of test data (kg)

Plant	Fiber amount	CalSil amount	RMI amount	Coatings/ Particulate amount
Plant 1	0.25	0	Large amount	155
Plant 2	4.6/3.2	0	0.2/0.8	6.6/12.0
Plant 3	0.7	8.1	9.5	22
Plant 4	2.1	0	0	21
Plant 5	0.1	0	0	1.142 (+Paint chips)

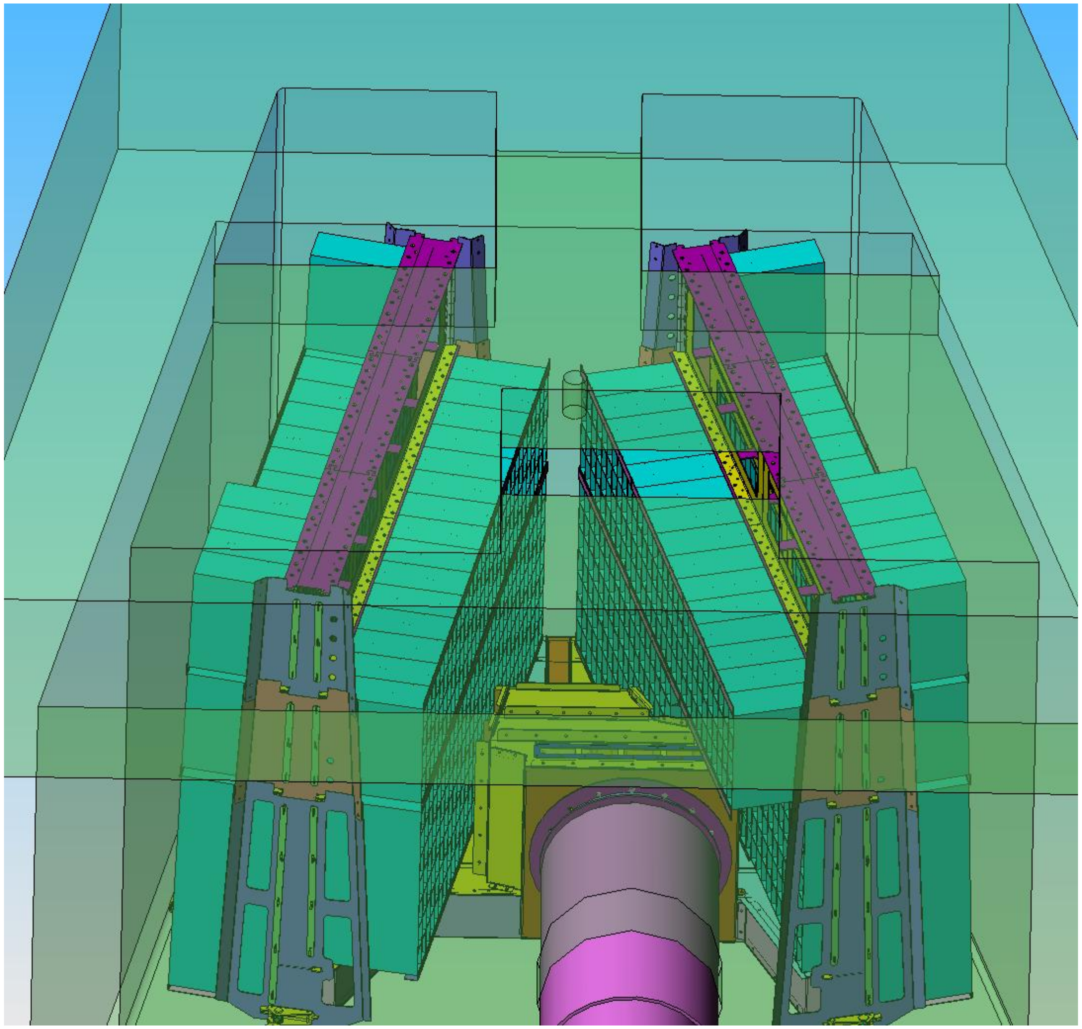
Plant 1 Strainer Installation



Plant 1 Strainer Installation



Plant 1 Strainer Installation



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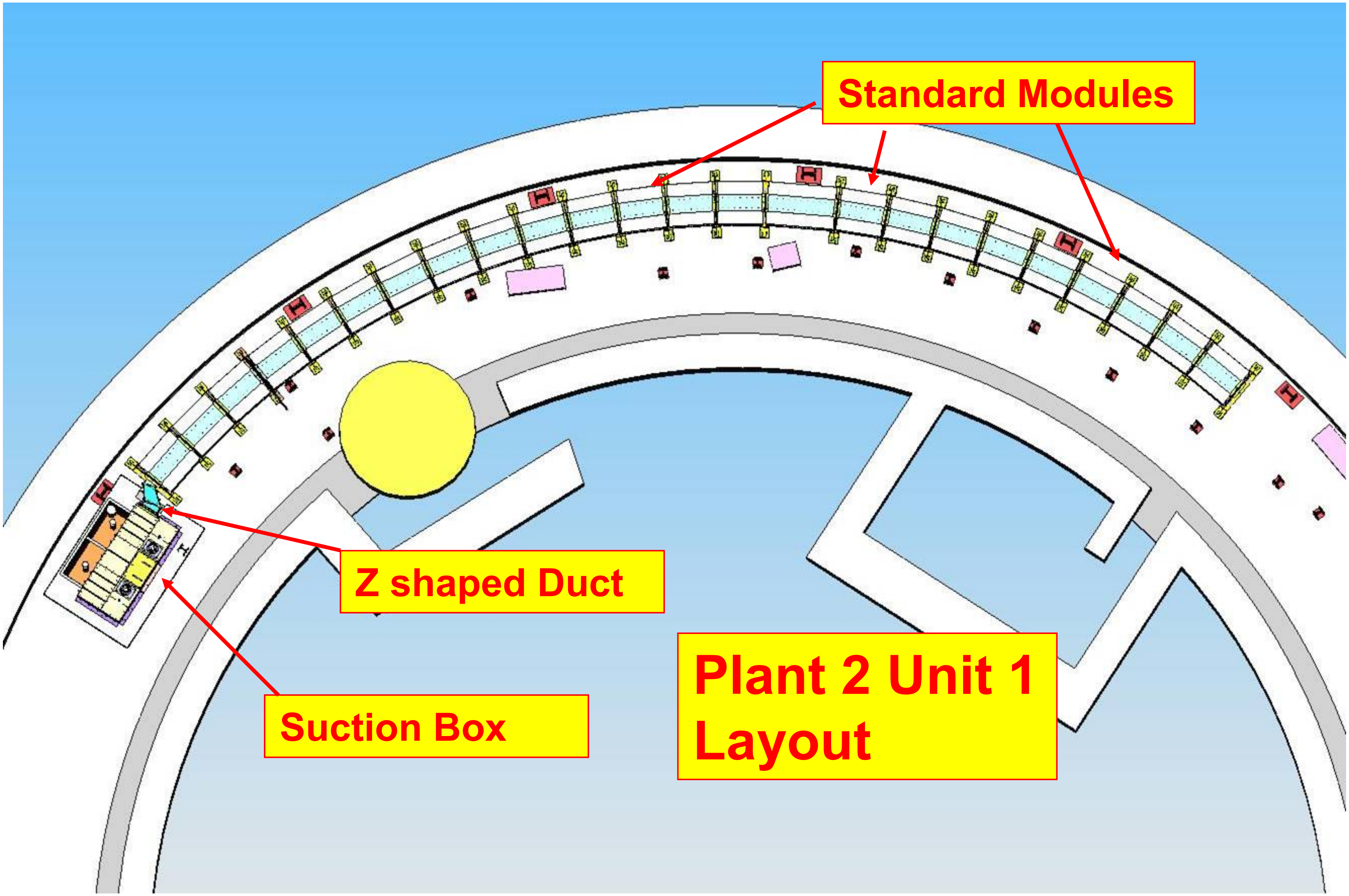
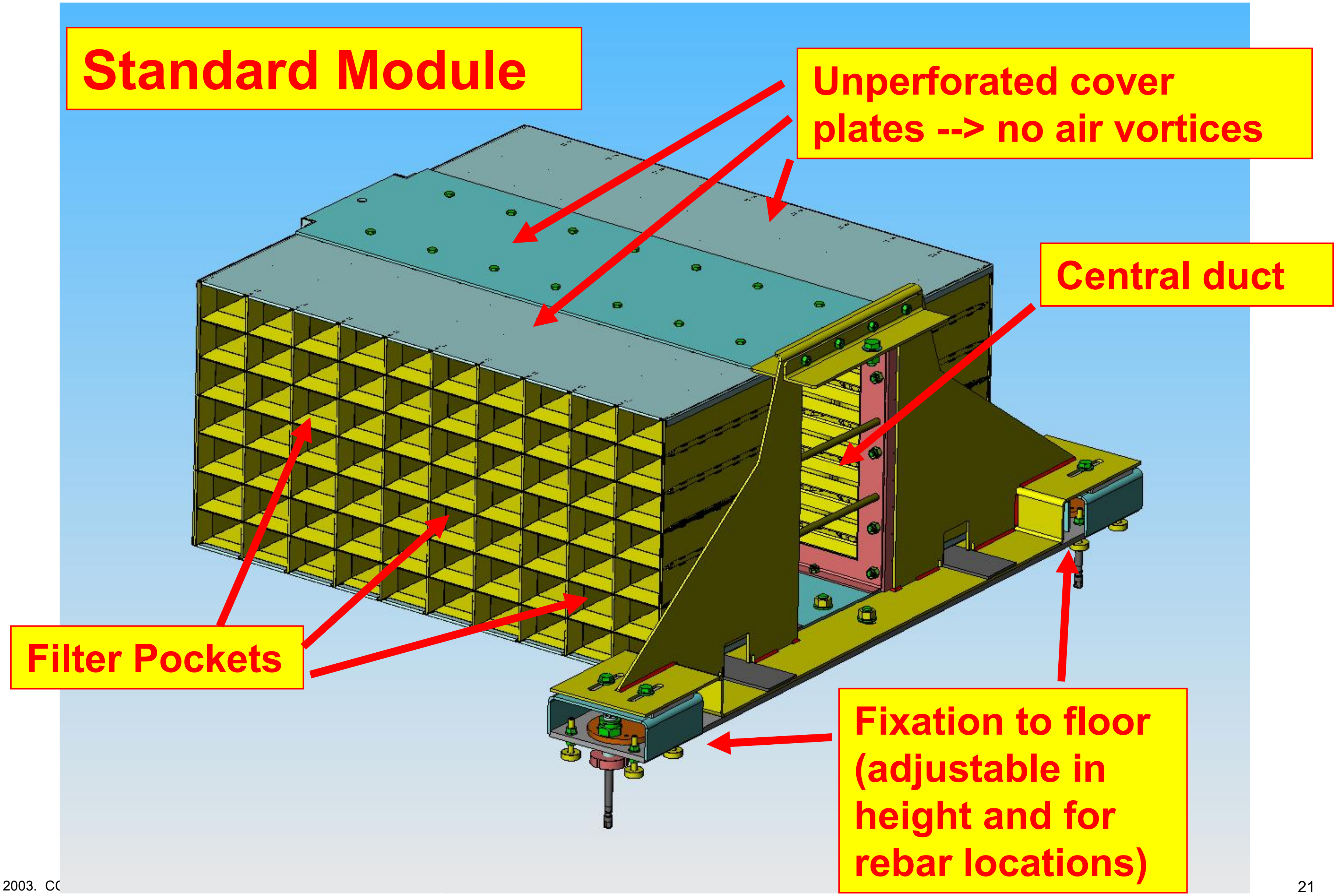
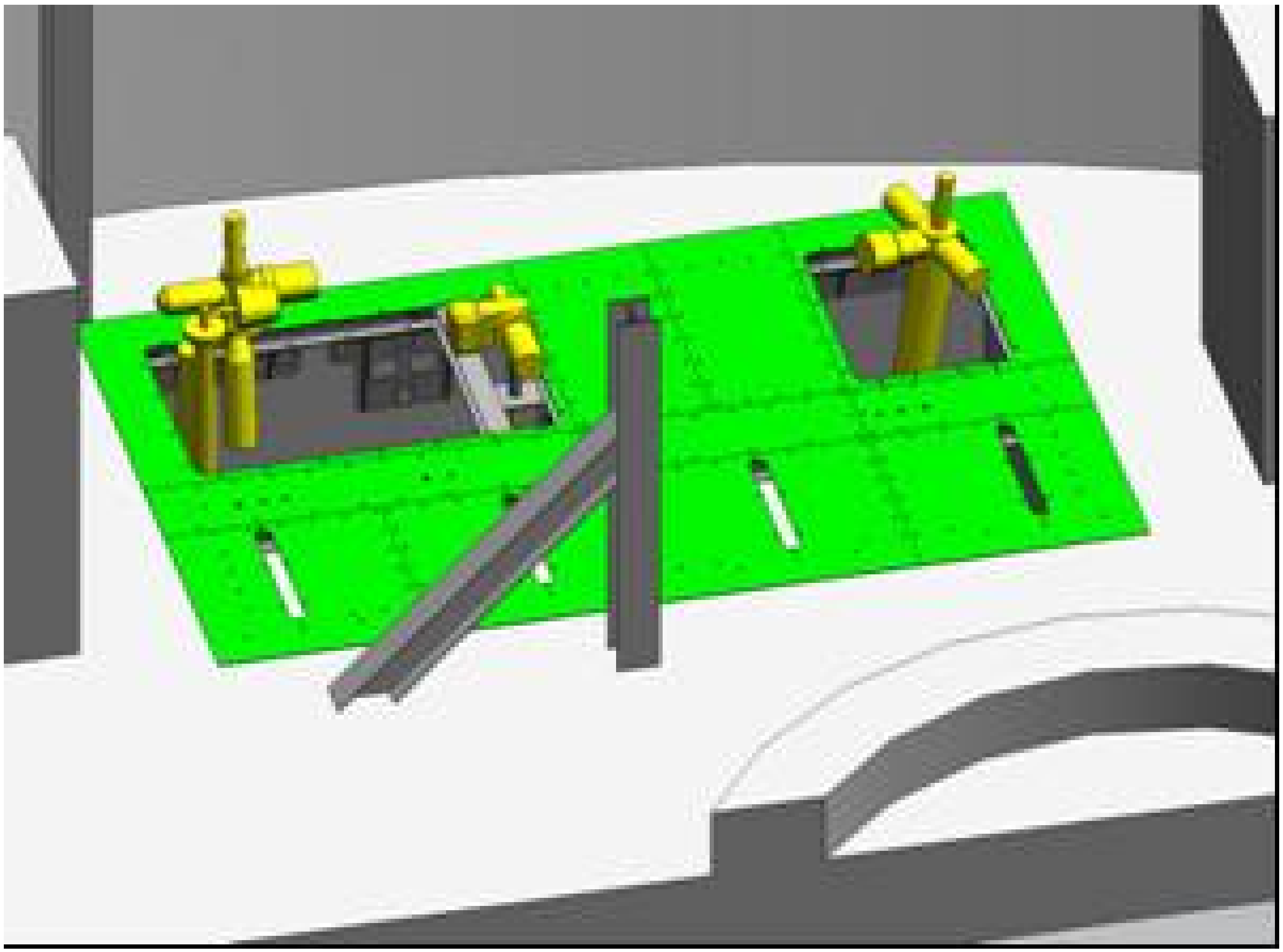
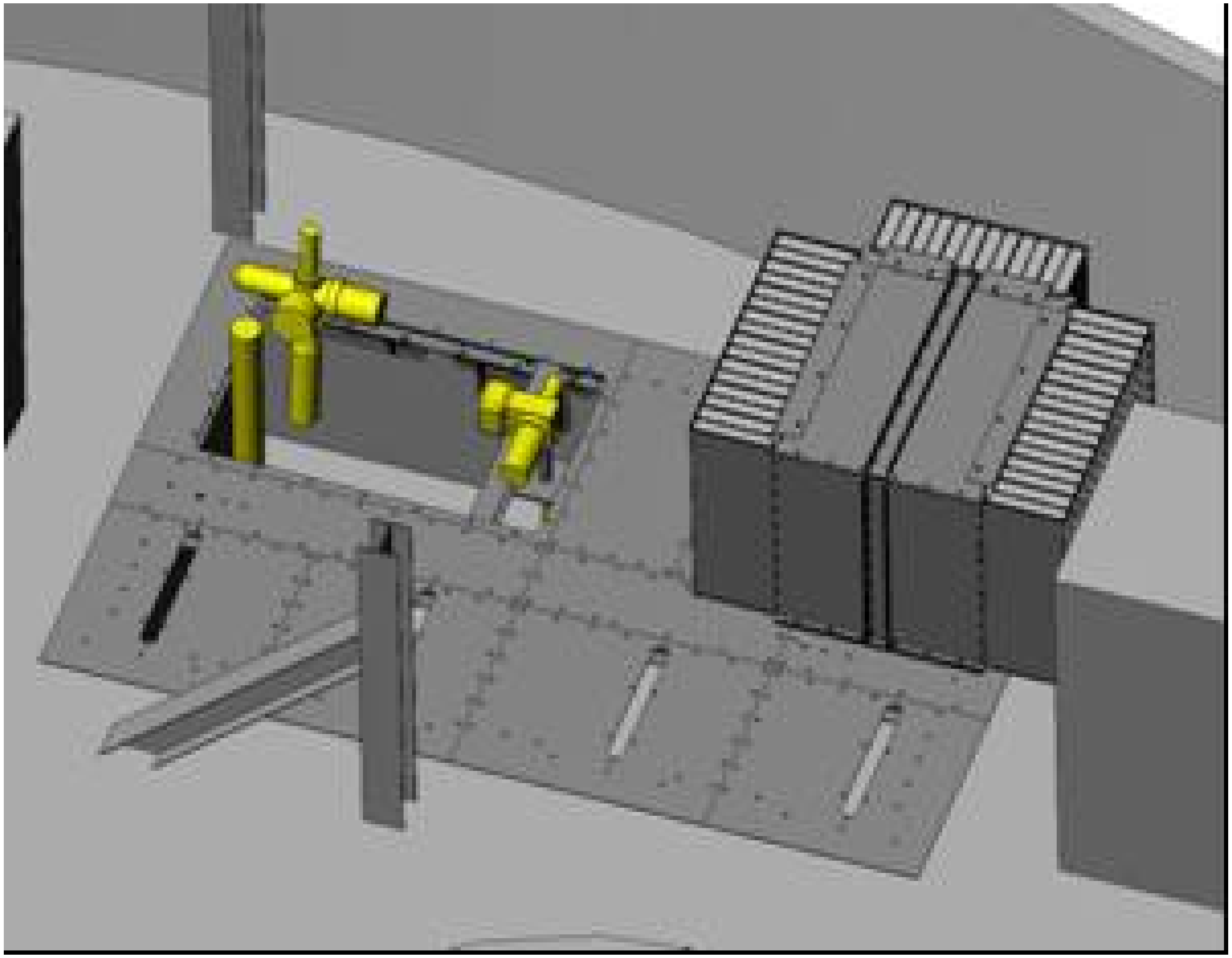



Standard Module
Unperforated cover plates --> no air vortices
Central duct
Filter Pockets
Fixation to floor (adjustable in height and for rebar locations)

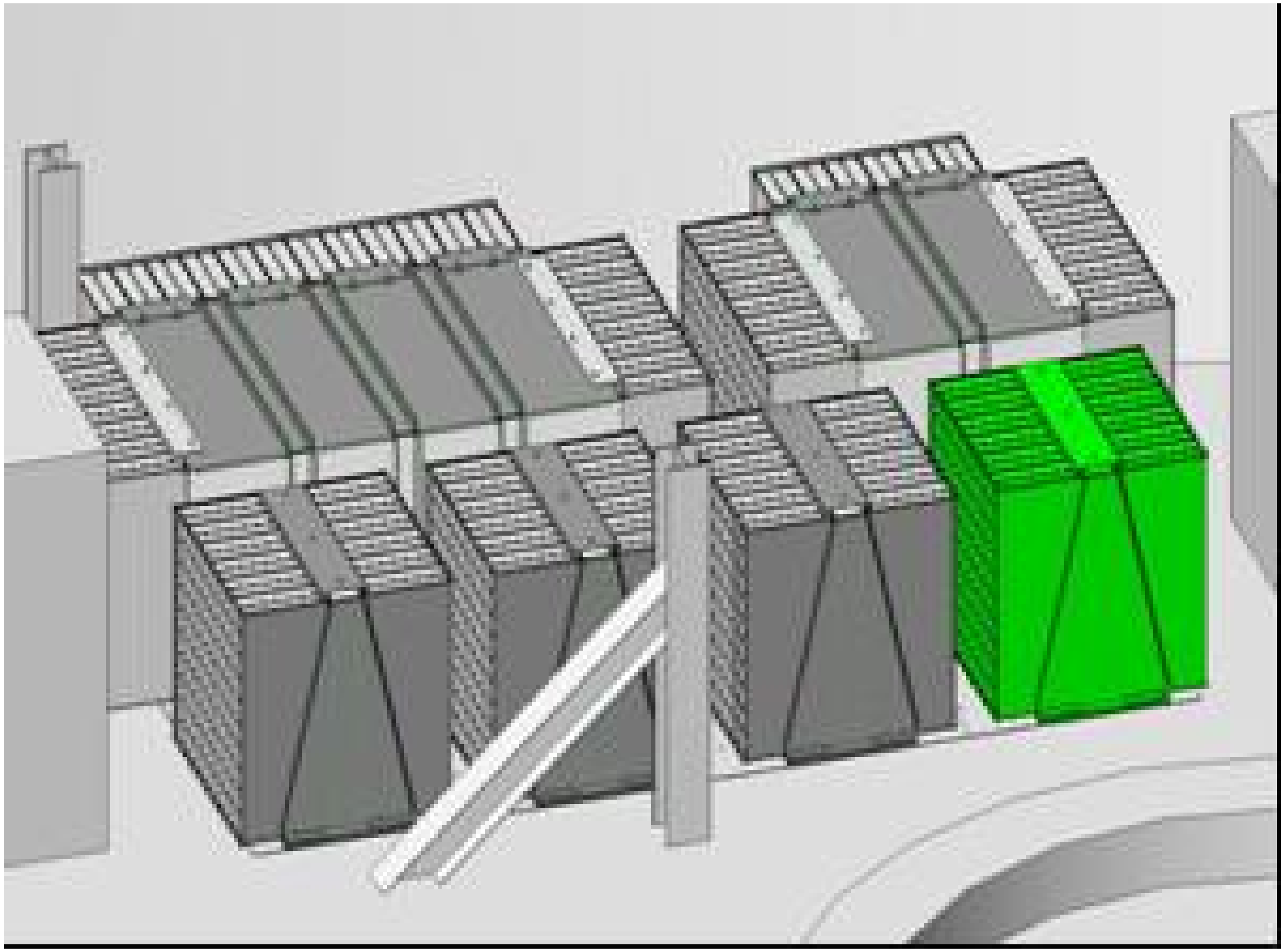
Plant 3 sump



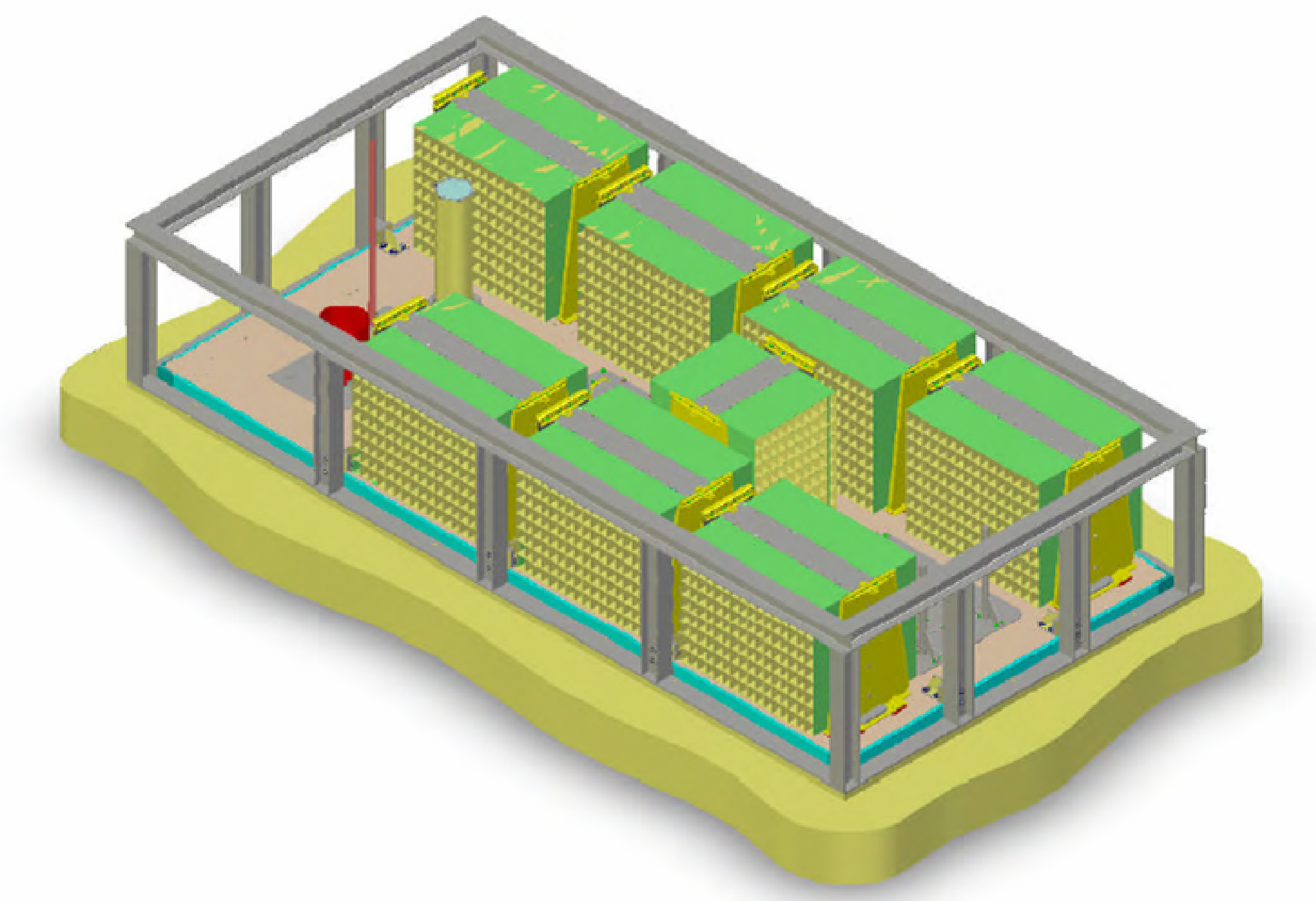
Plant 3 Installation first Module



Plant 3 Installation of last module



Plant 4 Installation



CCI testing experience for Plant 2

Type of testing	Debris types	Number of tests	Benefits of learning
Small scale testing	Nukon, Kaowool, Particulates, RMI	5+	Influences fiber type, RMI, thin bed
Large scale testing	Nukon, Kaowool, Particulates, RMI	5+	Influences fiber type, RMI, thin bed
Bypass testing	Nukon, Kaowool	9	Fiber amounts and sizes
Chemical testing	Nukon, Kaowool, Particulates, RMI, Chemicals	6+	Chemical behaviour over time

Chemical testing highlights

- Chemistry according ICET # 1, 2 and 4 (3 to follow soon for foreign plant)
- Room temperature
- Total Precipitate amounts set by WCAP methodology and filtering surface scaling
- Use of test loop as particle generator
  - avoiding analyzing one step more (for separate part.gen.)
  - precipitate concentration in loop closer to real plant
  - direct control/check of loop chemistry by sampling
- Pre-analyses by lab bench top testing
  - chemistry (effects of tap water and other debris)
  - filterability
  - settling rate
  - viscosity
  - precipitate size distribution

Chemistry testing steps for head loss

- Establishment of boric acid concentration
- Addition of TSP, Borax, if applicable
- Start of head loss testing with all other debris
- Slow addition of Sodium Aluminate rises pH
- Immediate precipitation of Aluminum Hydroxide in required quantity for filtering surface scaling
- Similar steps by adding calcium chloride and sodium silicate
- pH adjustment to reach wanted pH with Sodium Hydroxide or Nitric Acid, if required
- Continuation of head loss testing up to a predefined termination criteria
- Sampling of loop solution at specified time for lab analysis
- Integration of chemical head loss results in final plant head loss report

Basic layout of MFT loop

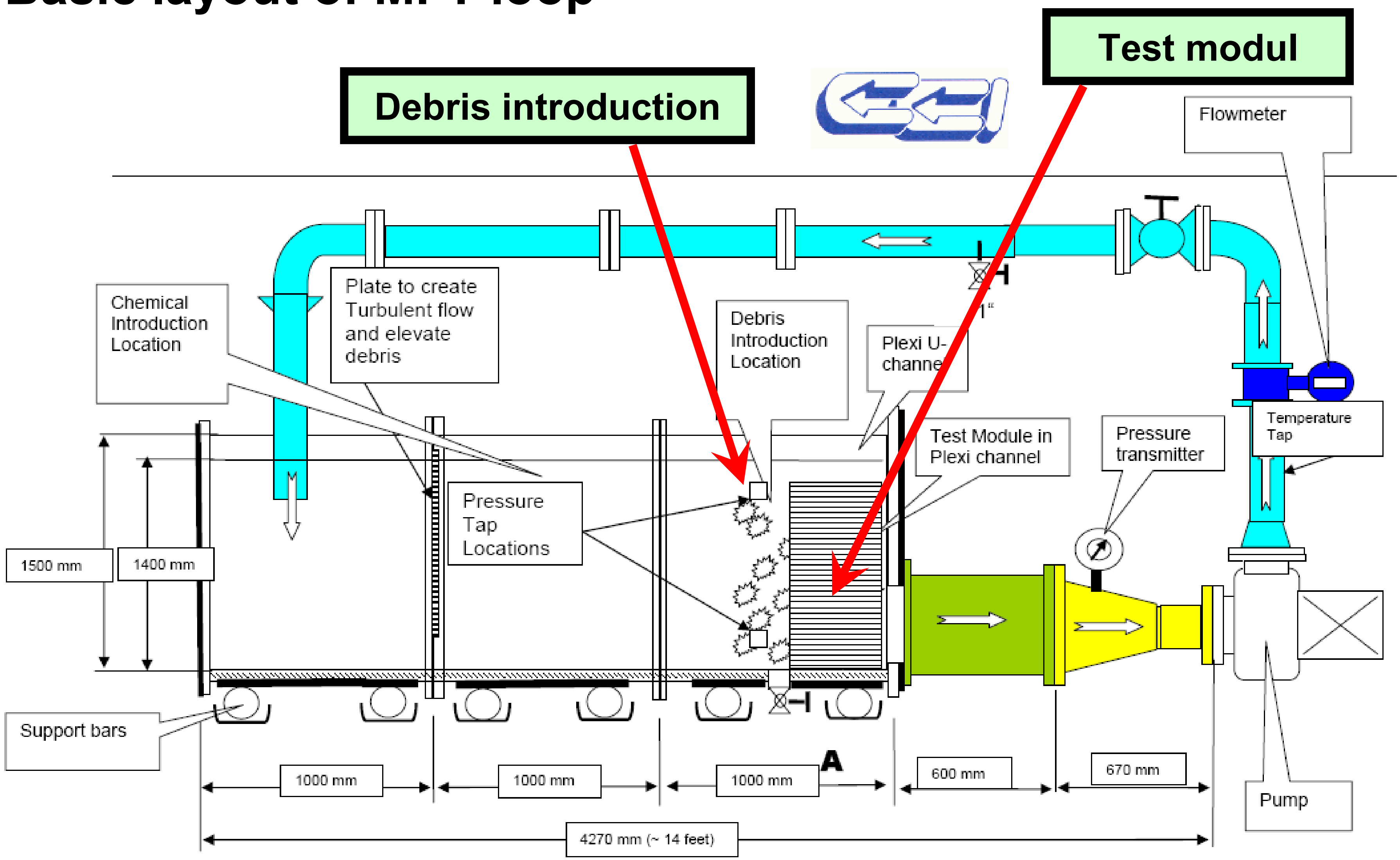
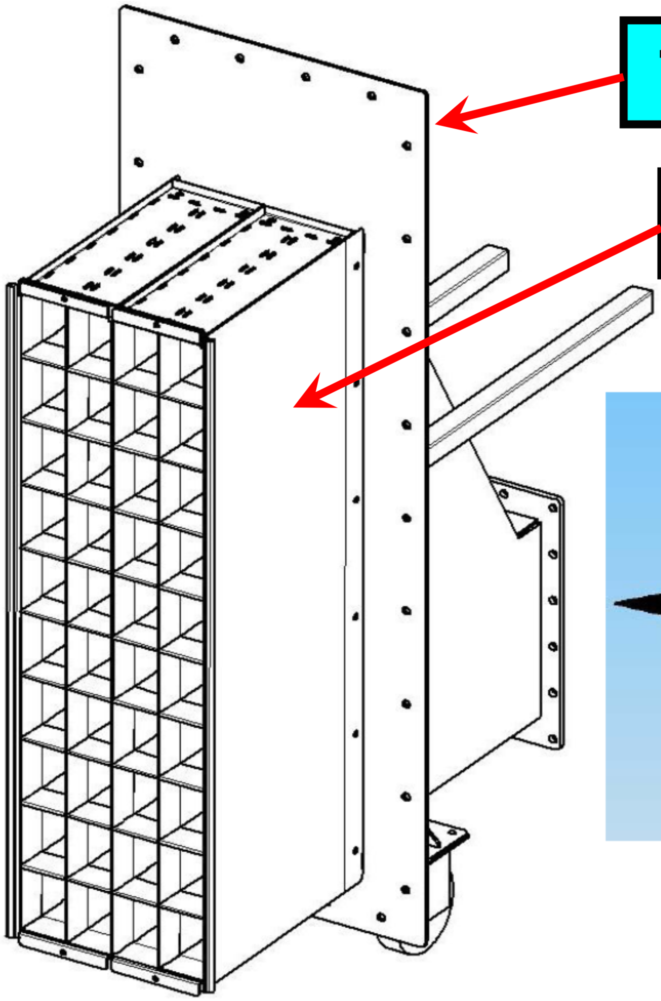
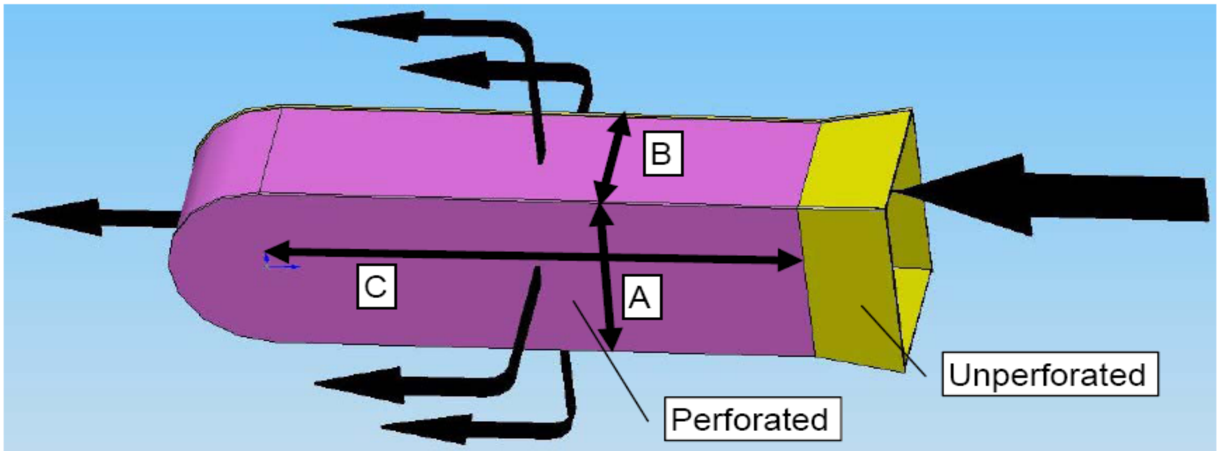


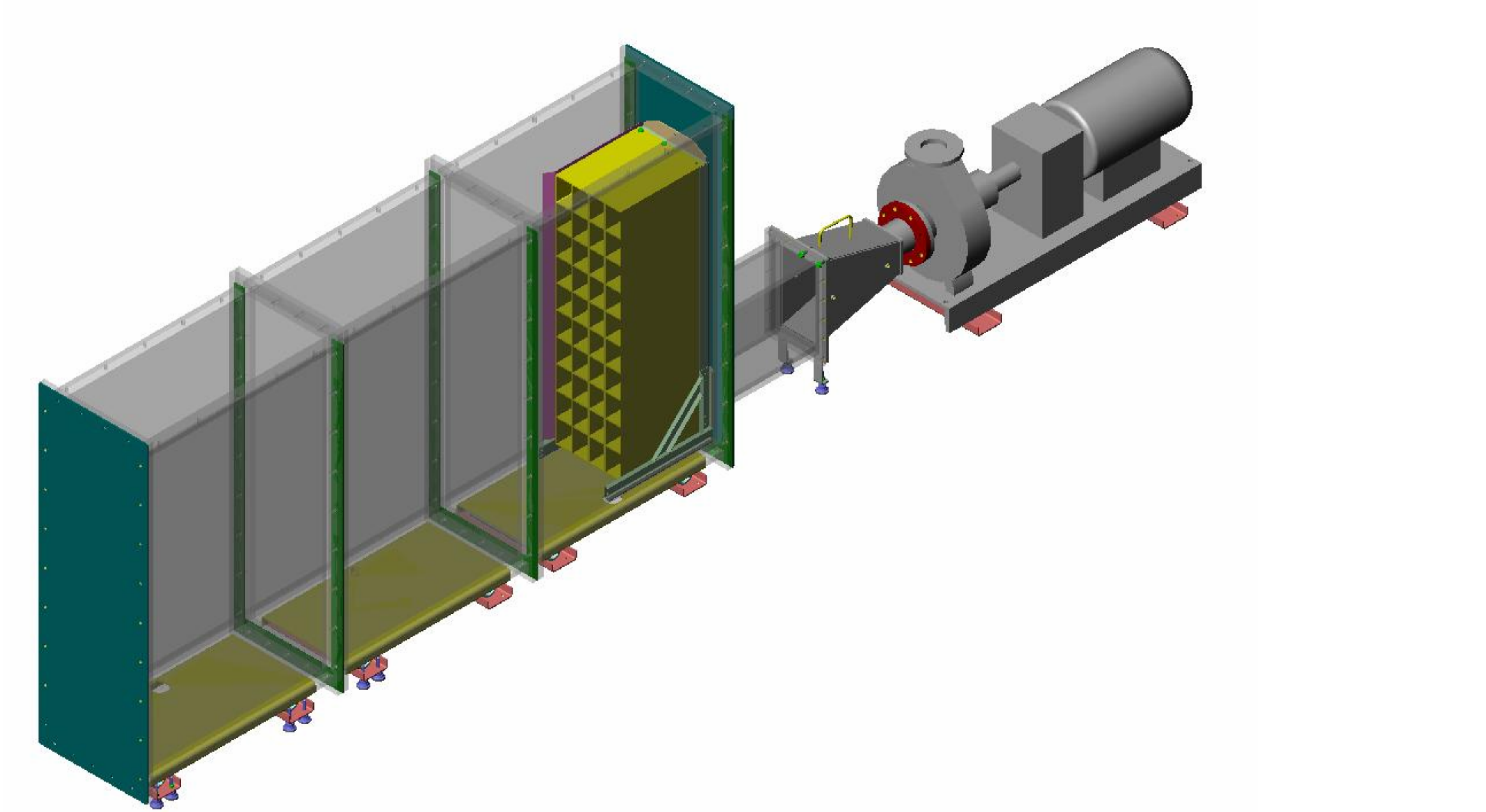
Figure 1: CCI Strainer Test Loop

CCI pocket strainer design

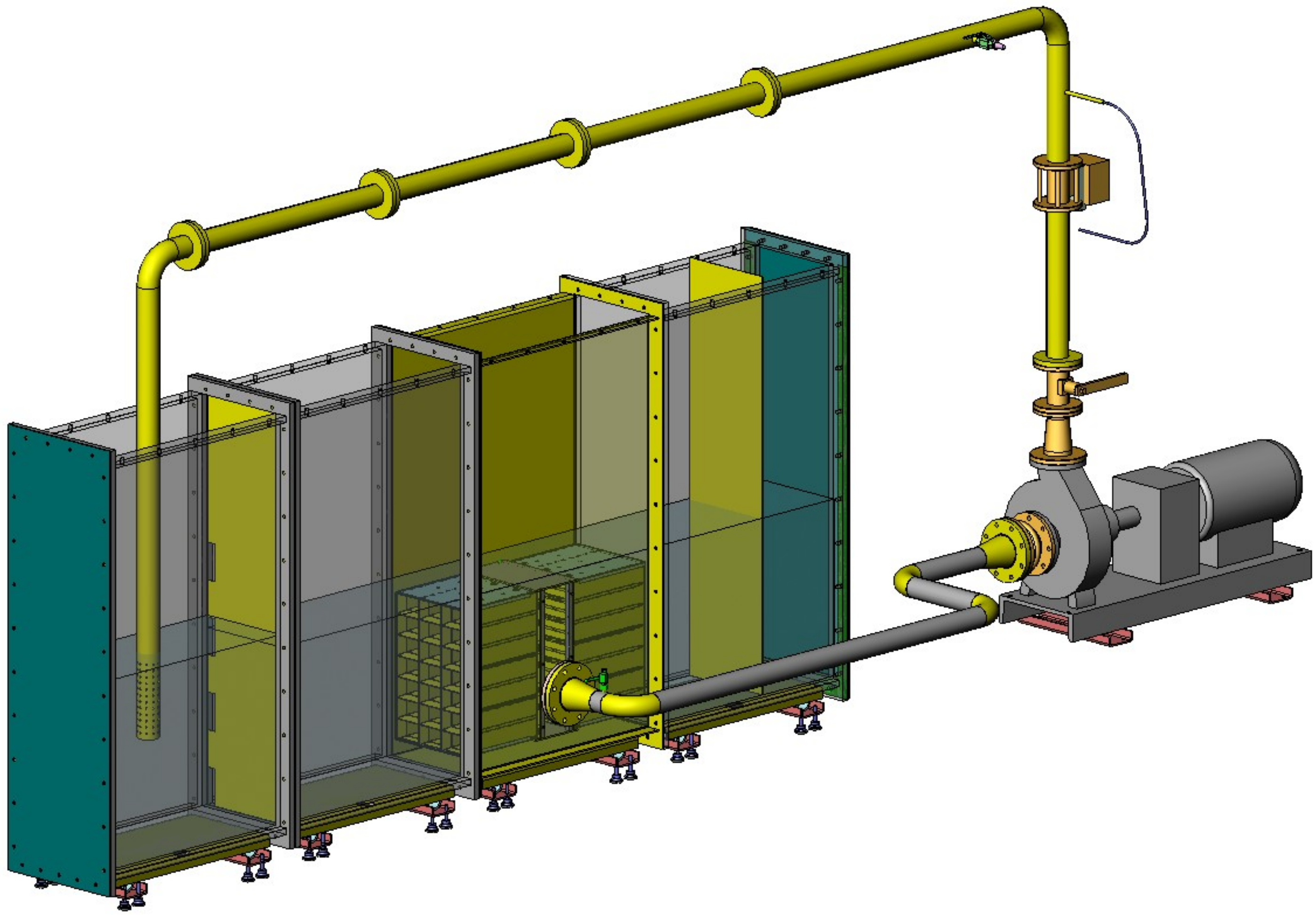




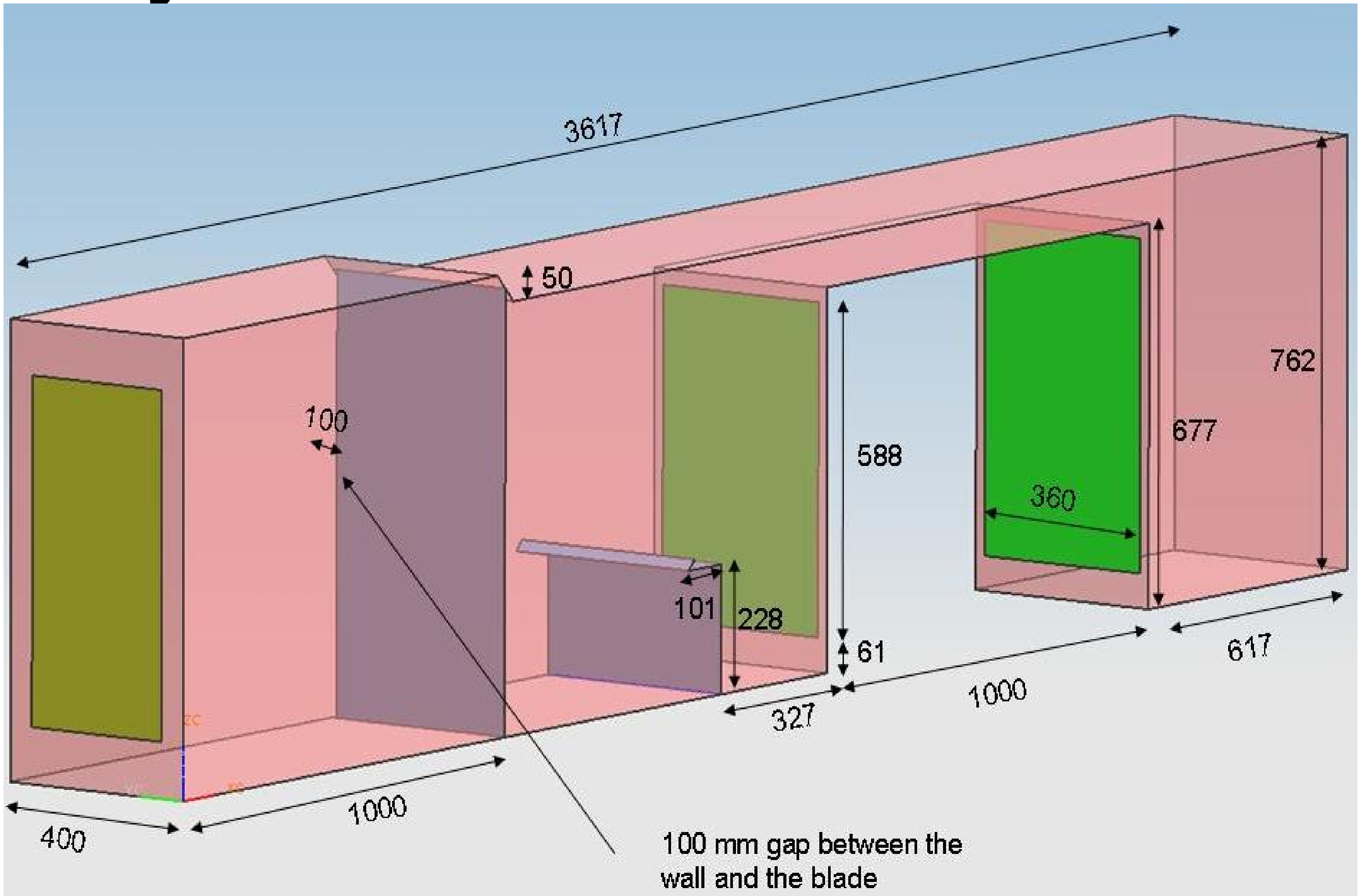
Testing arrangement with 40 pockets



Testing arrangement with double sides



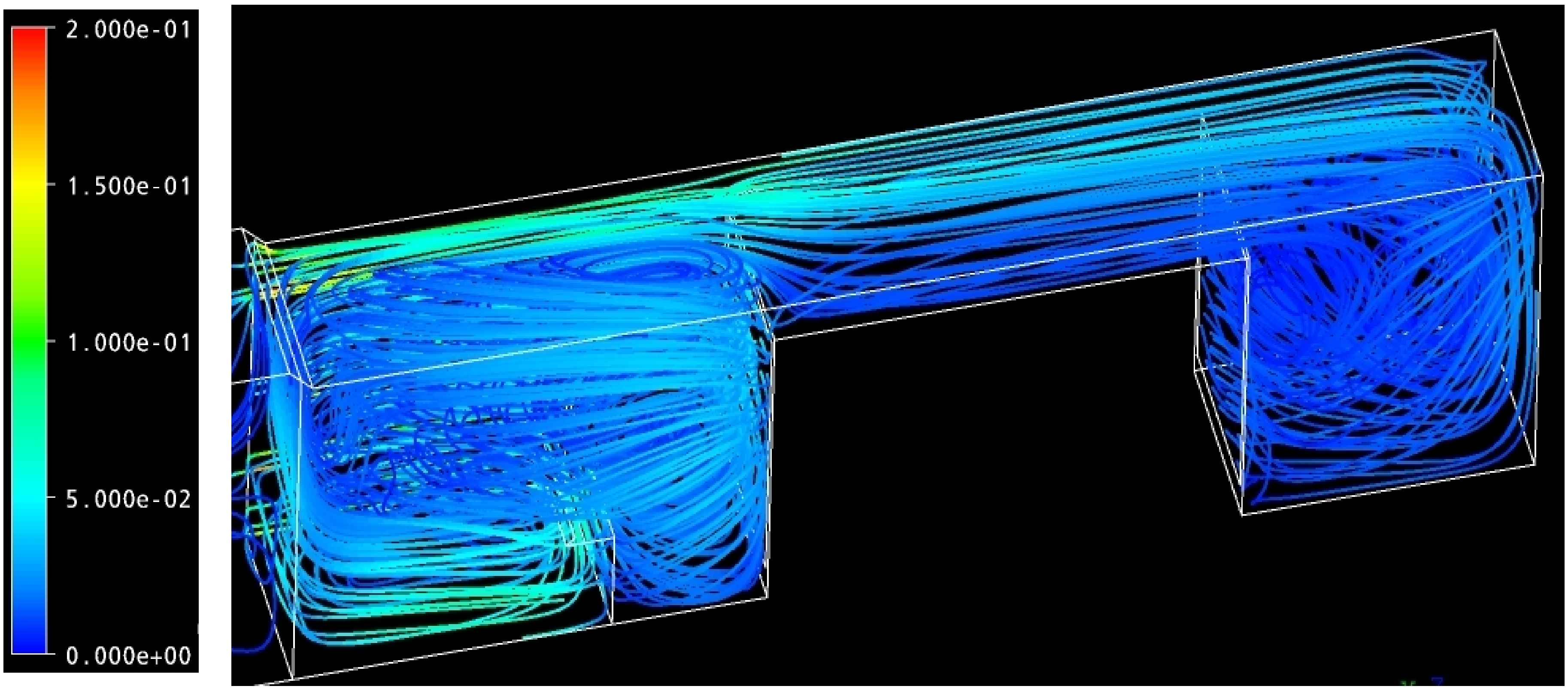
Geometry


3617
50
762
677
588
360
100
101
228
61
327
1000
617
400
1000
100 mm gap between the
wall and the blade

Streamlines

Velocity

[m/s]

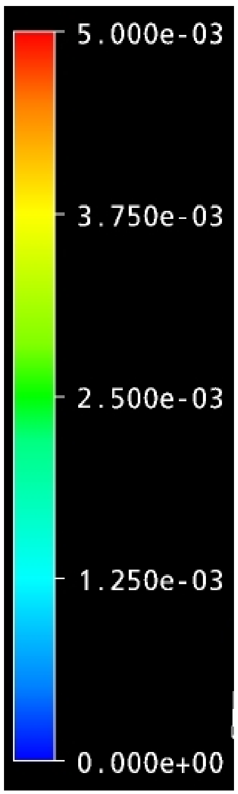


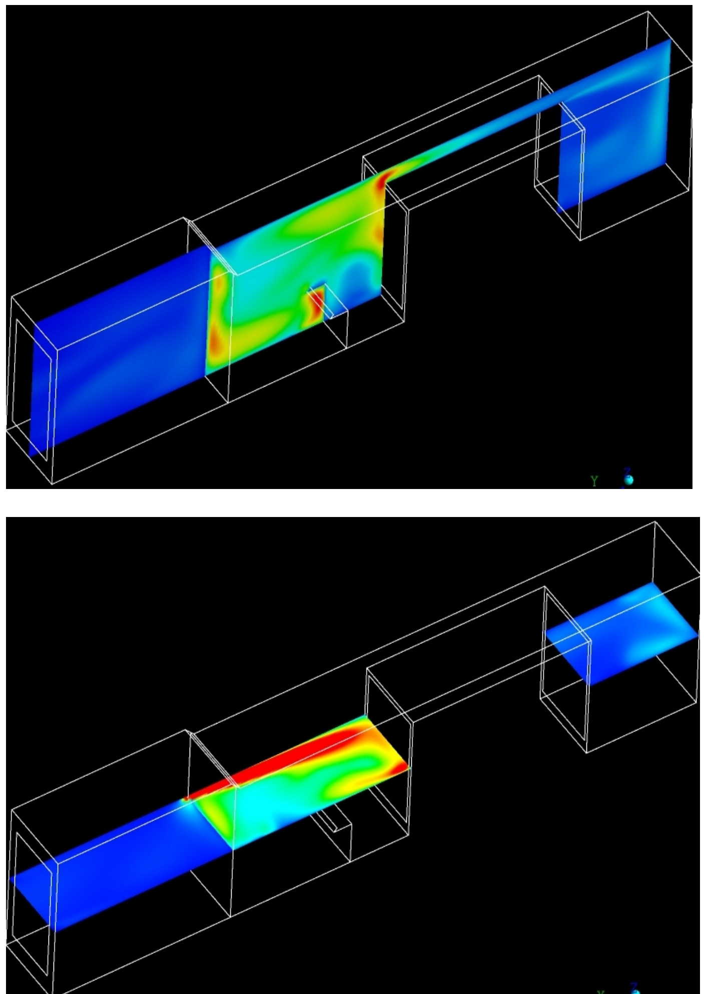
Turbulent kinetic energy

The blade induces high turbulent kinetic energy

TKE

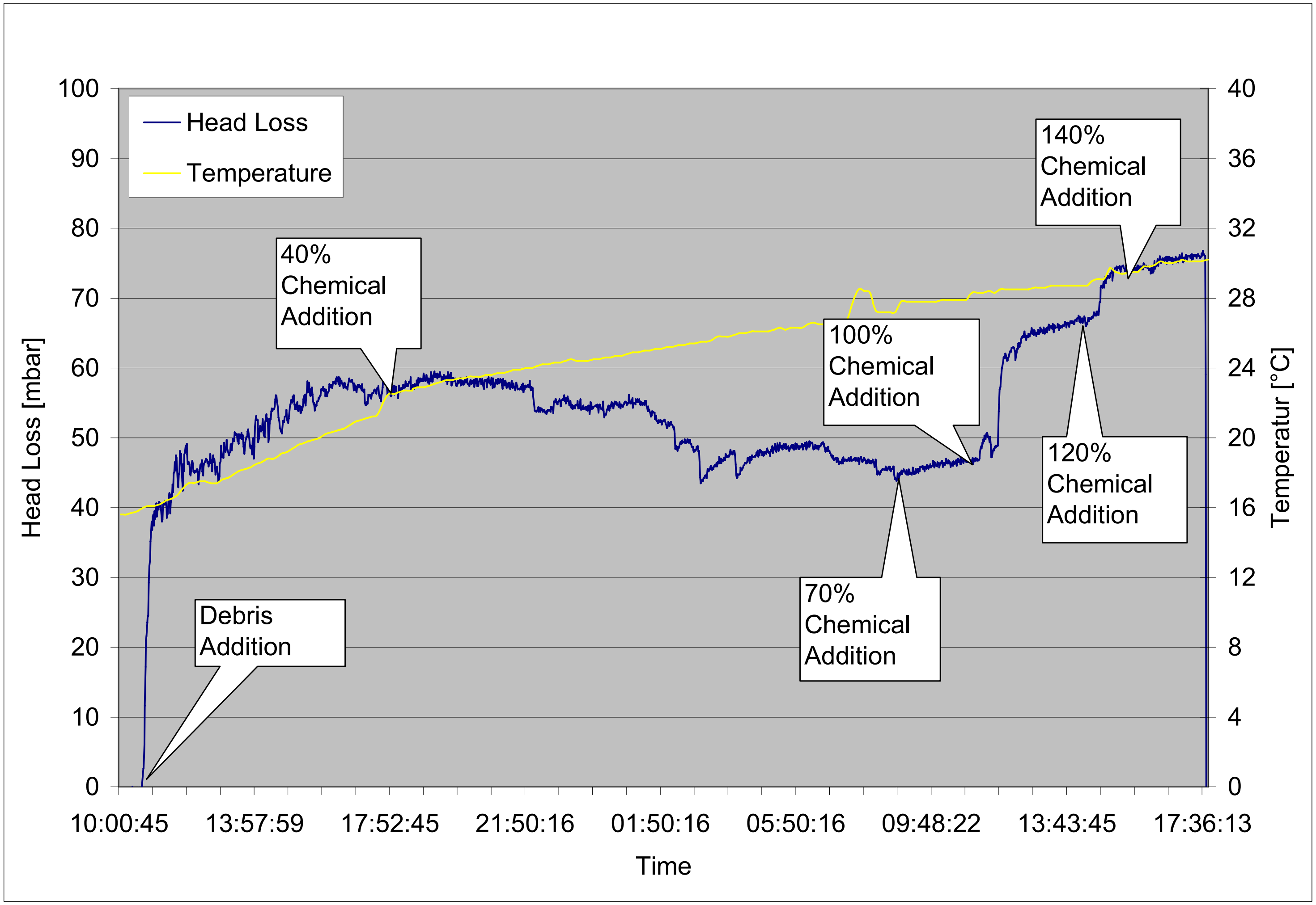
[m²/s²]



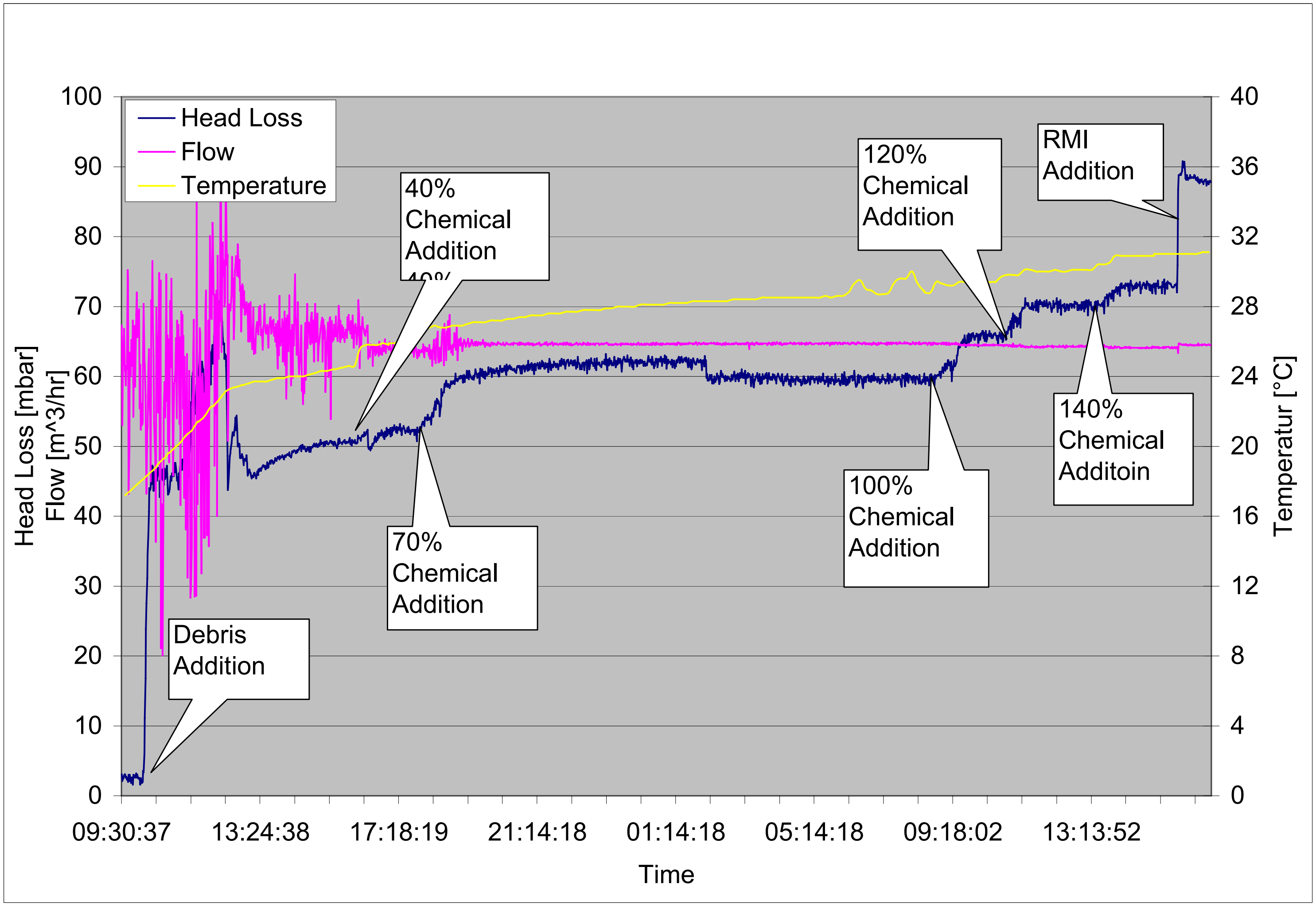


Plant 1 Chemical Test

Plant 1 Chemical Test #4



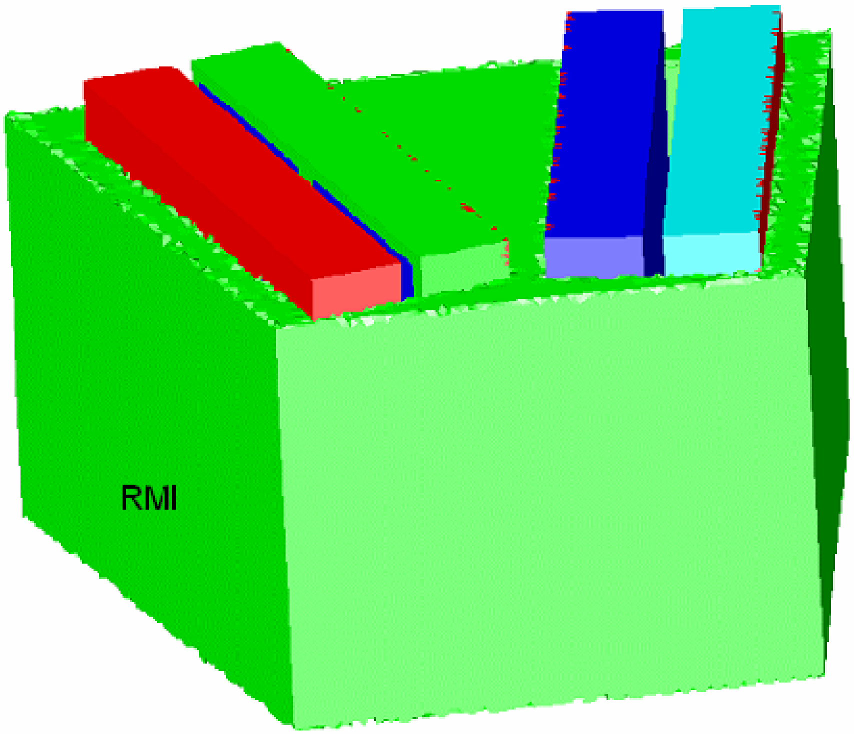
Plant 1 Chemical Test #5



Plant 1 RMI space consumption

CCI – Internal strainer channel flow

Filling height of RMI



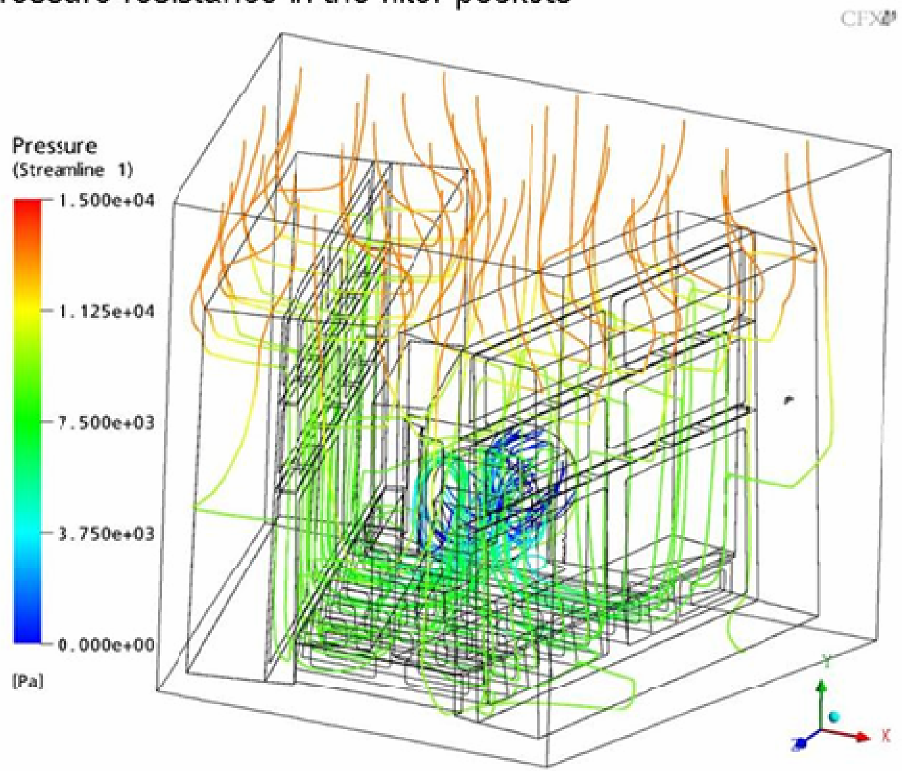
CCI / 08.05.05 / J.Schöd - A 4

Plant 1 overall CFD calculation

CCI – Internal strainer channel flow

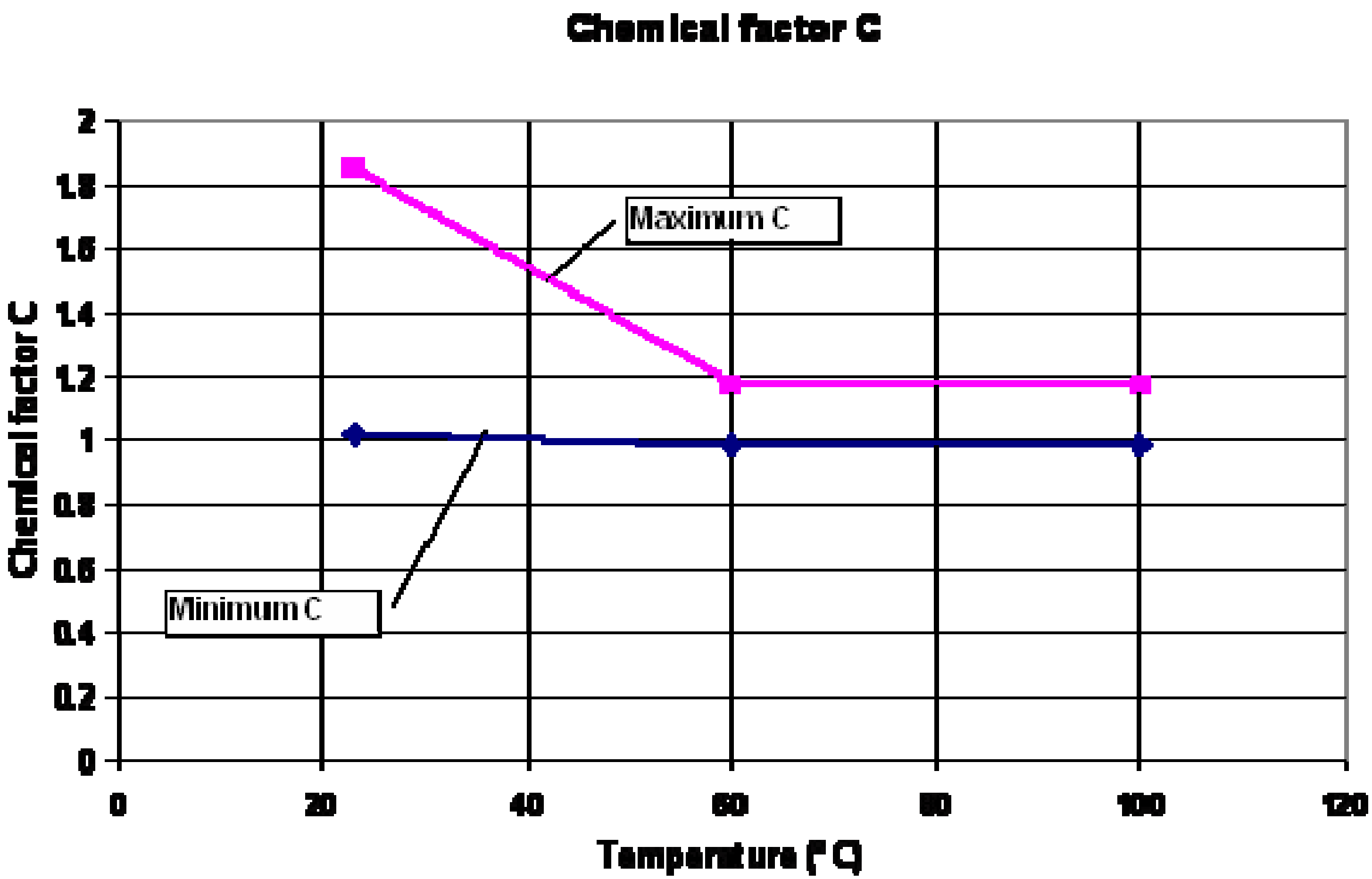
Streamlines colored by pressure

medium pressure resistance in the filter pockets

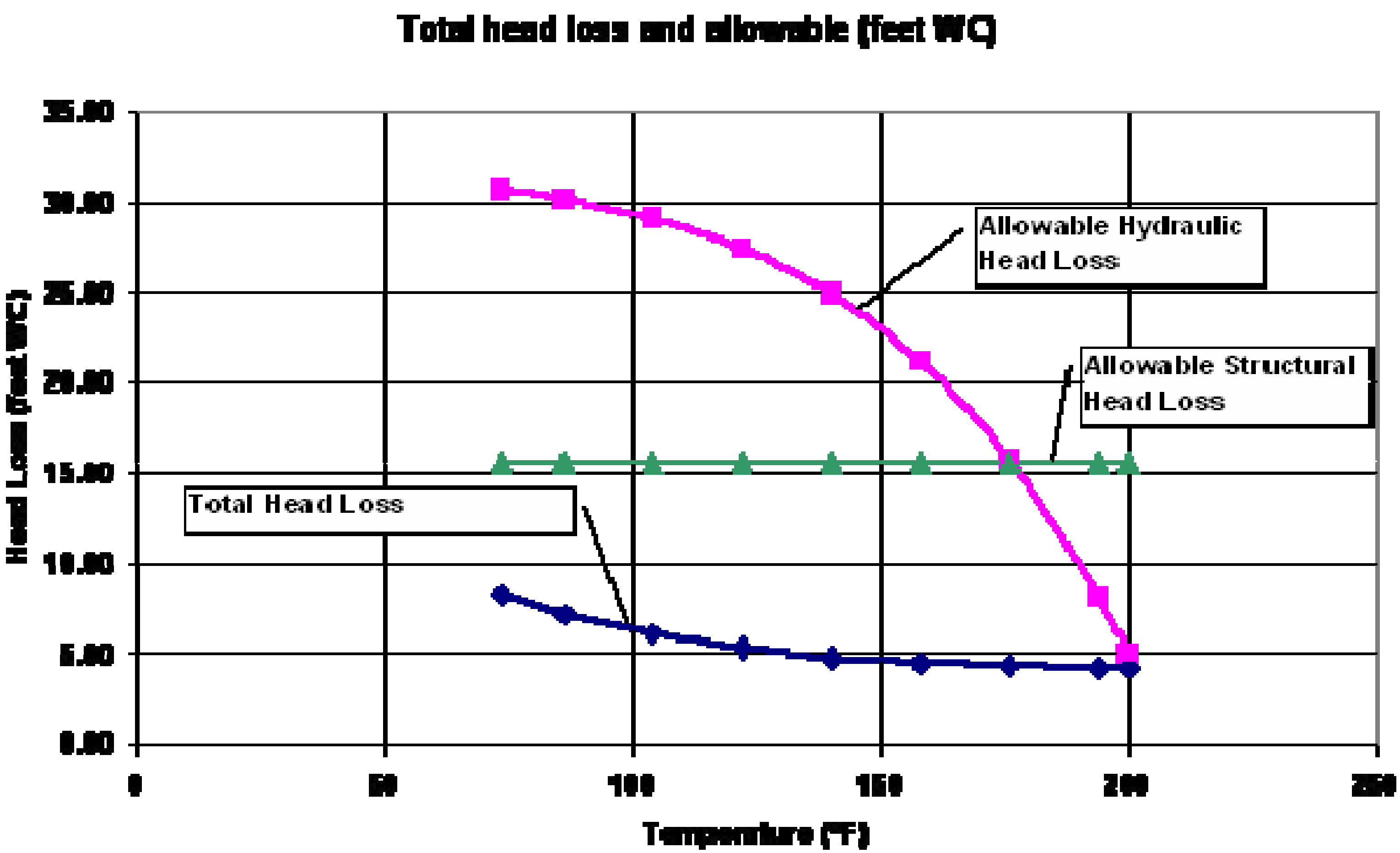


CCI/ 08.05.06 / J. Schöck - A5

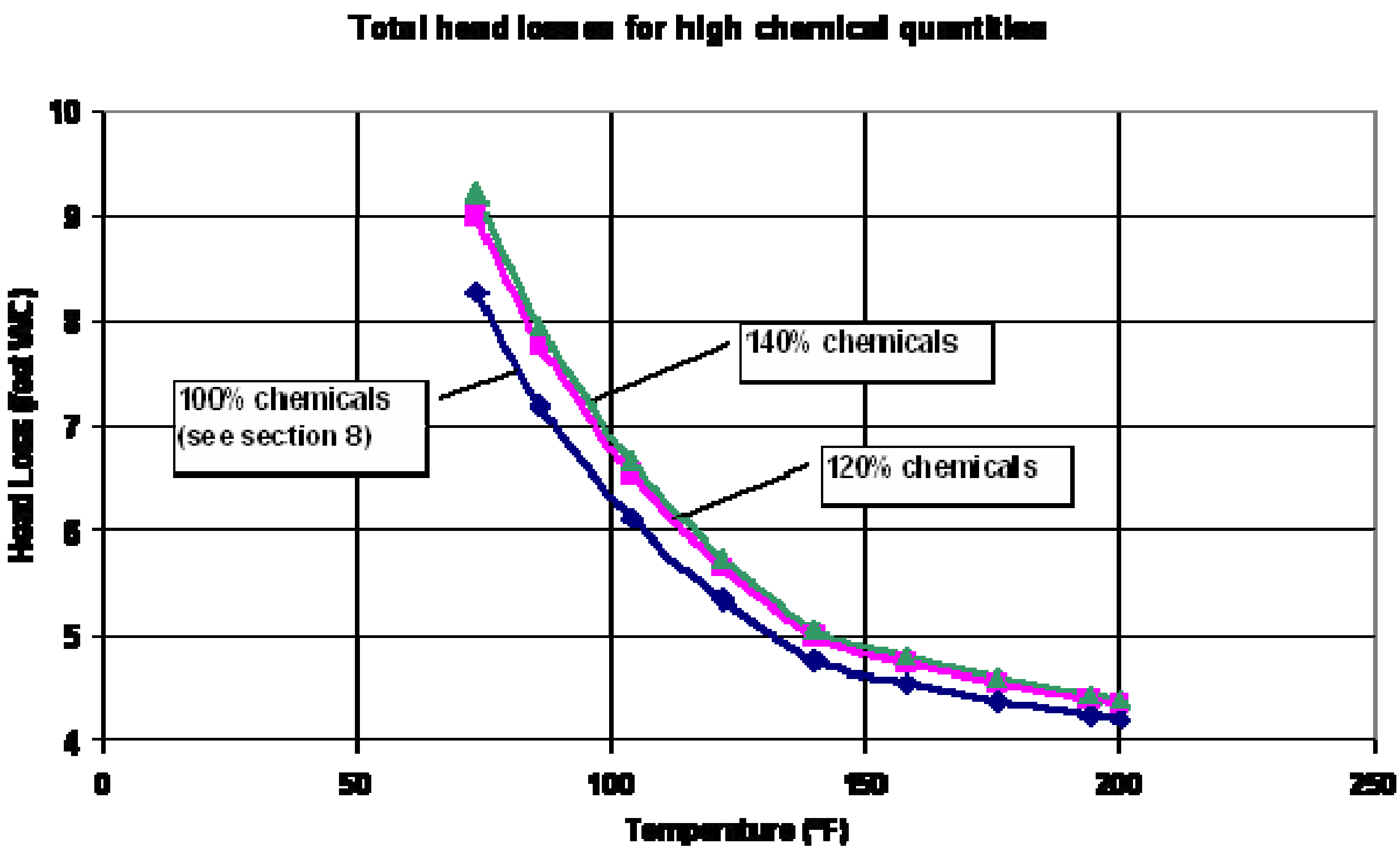
Influence of chemistry on Viscosity (derived from ICET tests at high flow shear rates)



Final overall head losses for Plant 1



Plant 1 : Influence of chemicals



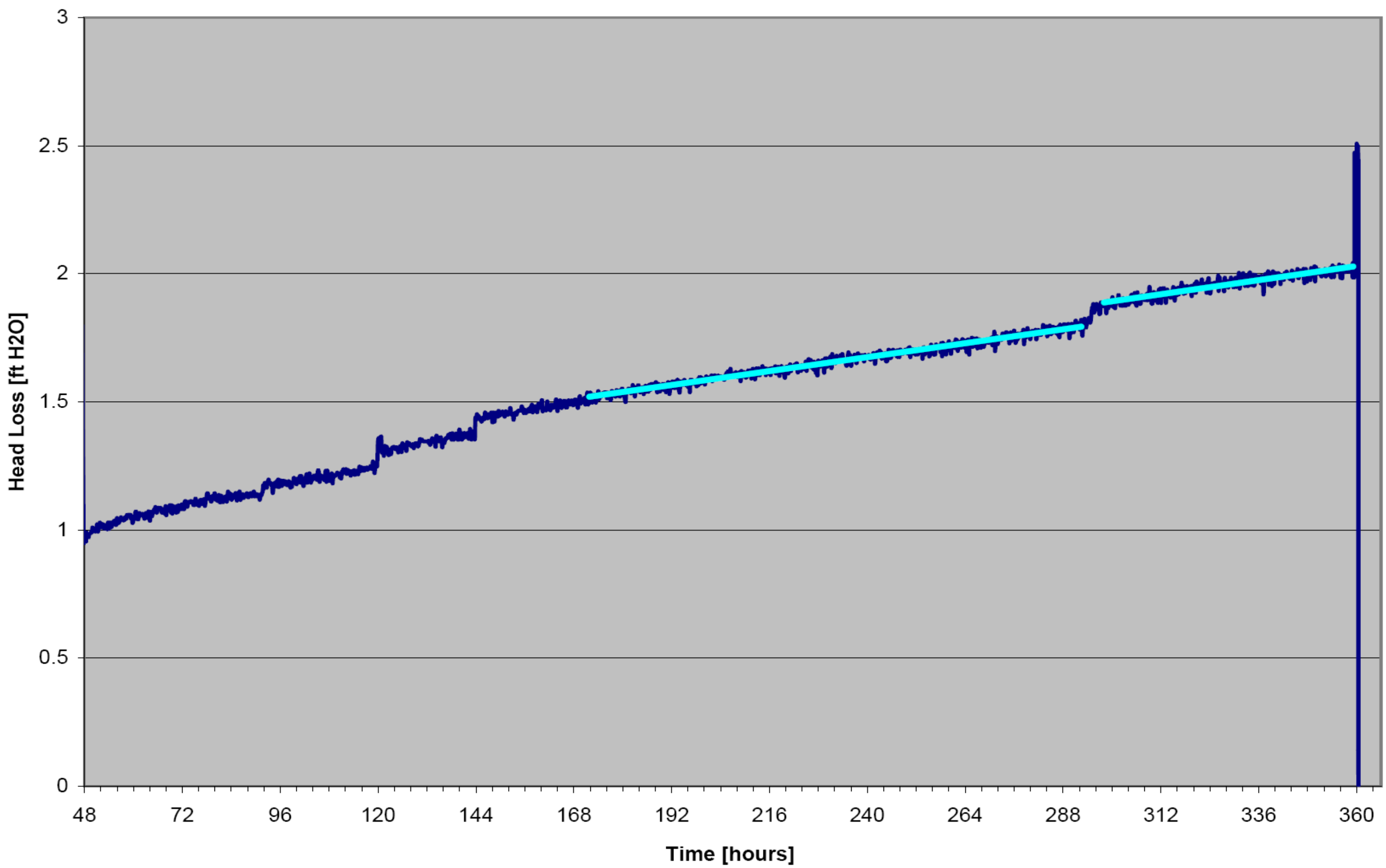
Head Loss testing with Chemical Effects (Plant 2)

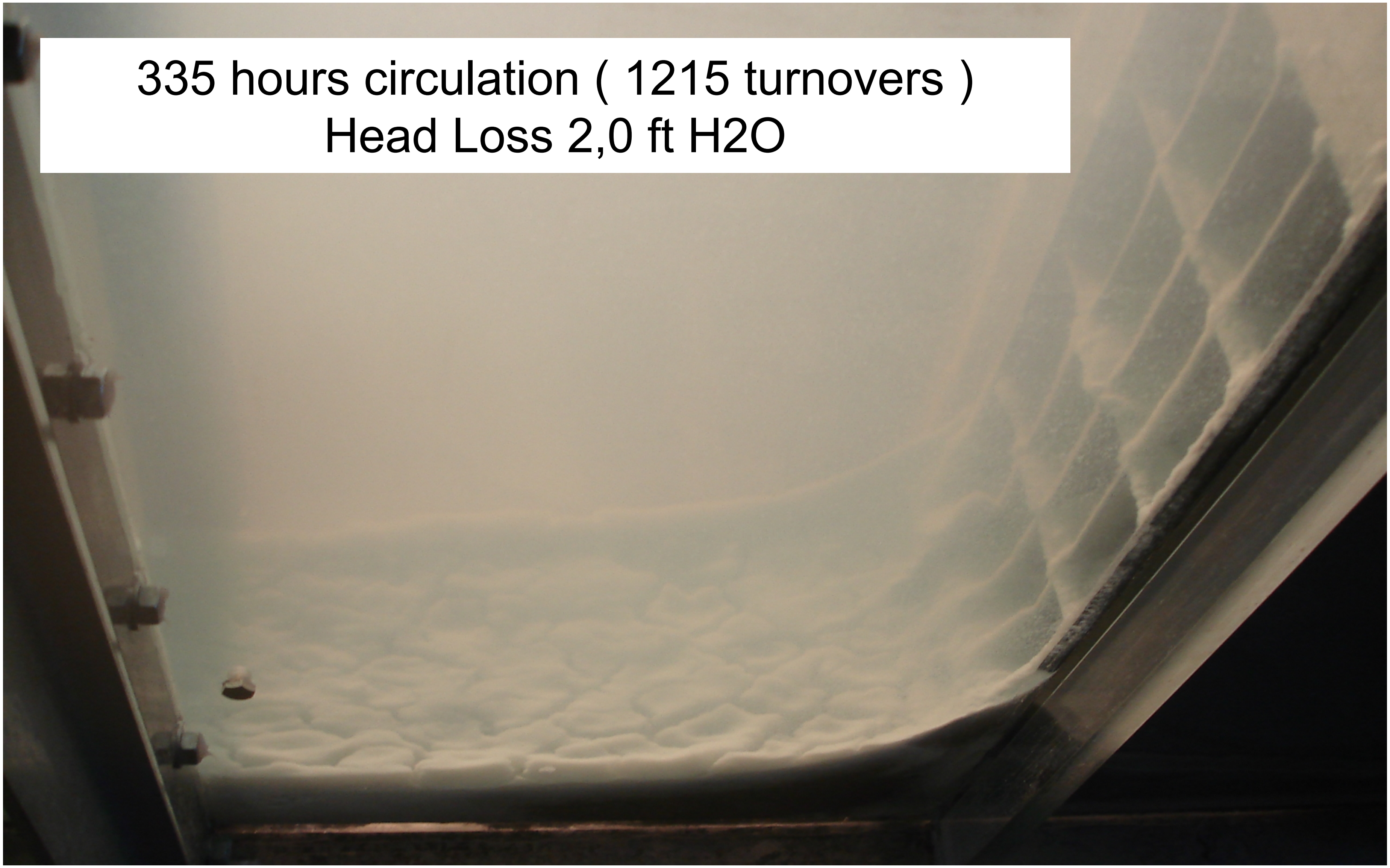
- Test Filter surface — 26,8 ft^2
- Filter surface approach velocity — 0,0046 resp. 0,0026 ft / s
- pH — 8,0 – 8,4
- Debris bed thickness — 1,6 in
- Fiber – Particulate ratio — 0,74
- Water turnovers per hour — 6,3 resp. 3,6
- Test performed at ambient temperature

Debris	
Nukon	7.582 ft3
Kaowool	2.600 ft3
Min-K	0.542 ft3
Coating + Particulate	14.52 lb

Chemicals		
Boric Acid		2500 ppm
Sodium Aluminat	4.38 lb	0.10 %
Sodium Silicate	6.58 lb	0.15 %

Chemical Test
Approach velocity 0,0026 ft/sec



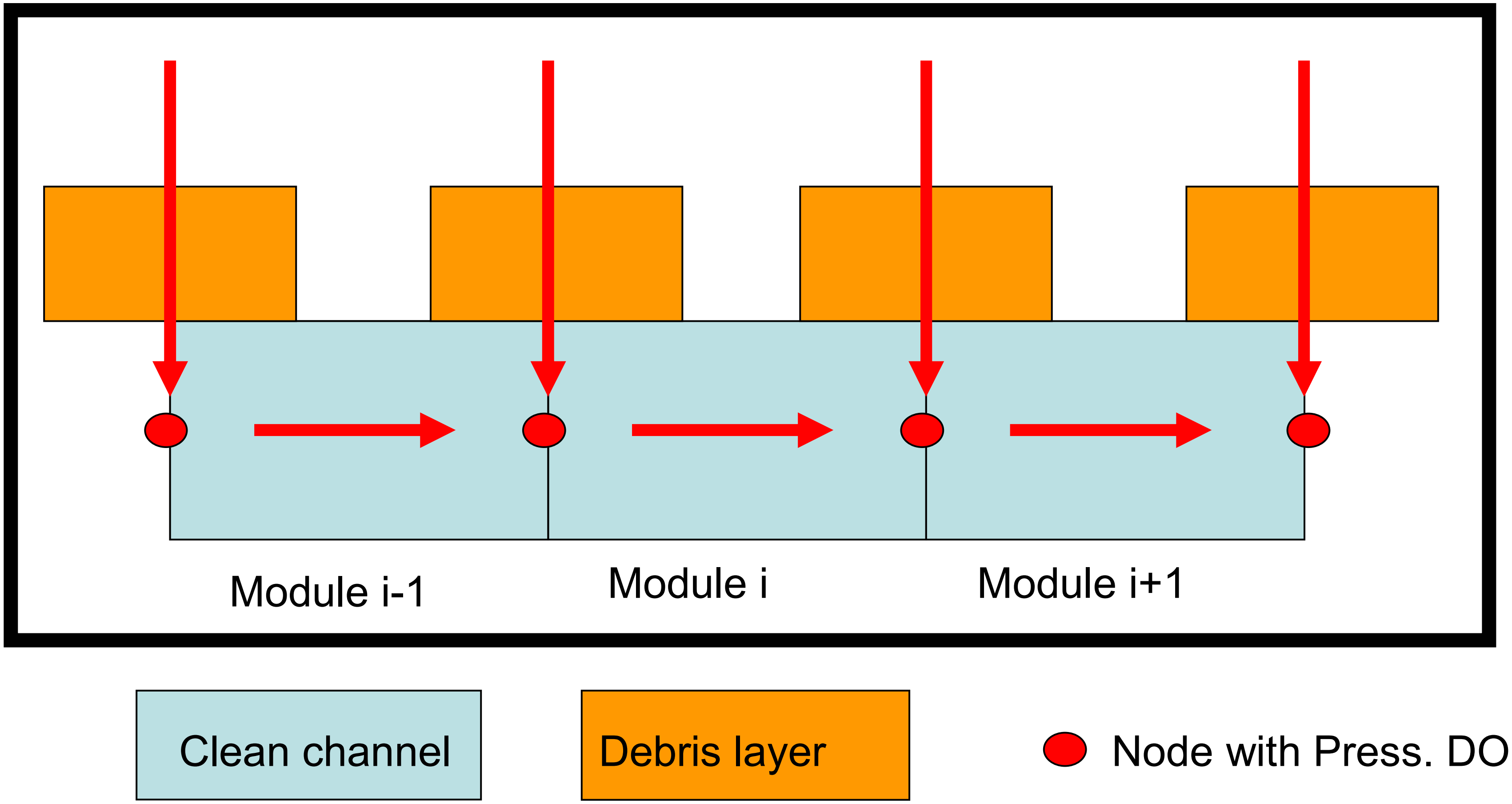

335 hours circulation (1215 turnovers)
Head Loss 2,0 ft H2O

RMI added at the end

View into the pockets after test

View into the test loop after test

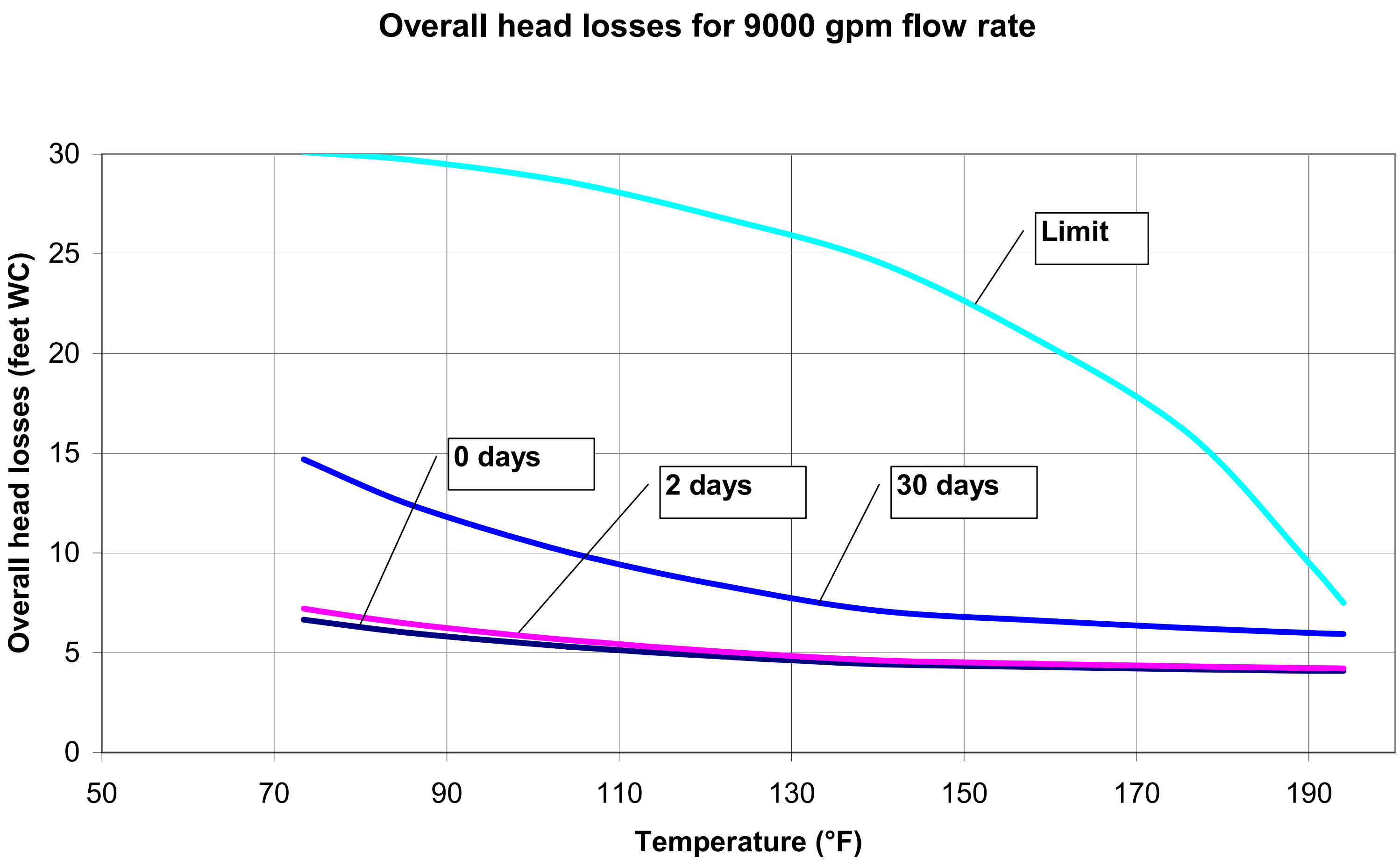
Finite Difference Scheme for Head Loss



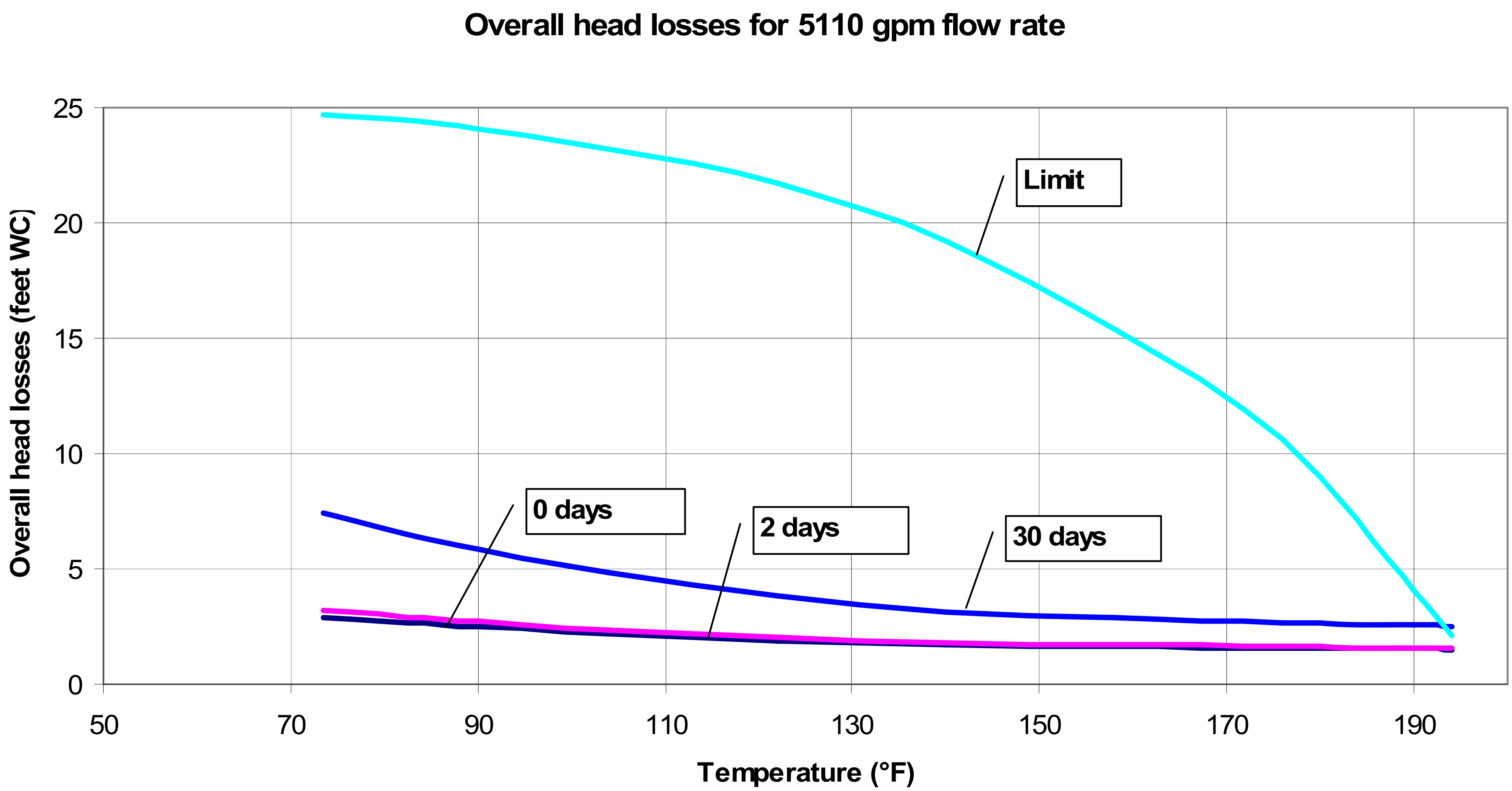
Overall Head Loss Determination Steps

- Identification of DEBRIS Head Loss as a function of time, temperature and debris loading thickness
- Finite Difference Model computation of whole train of strainer modules with debris head loss into each module and axial clean head loss through each module, from flow start to sump pipe
- Result : Head losses as function of time, temperature and flow rate.

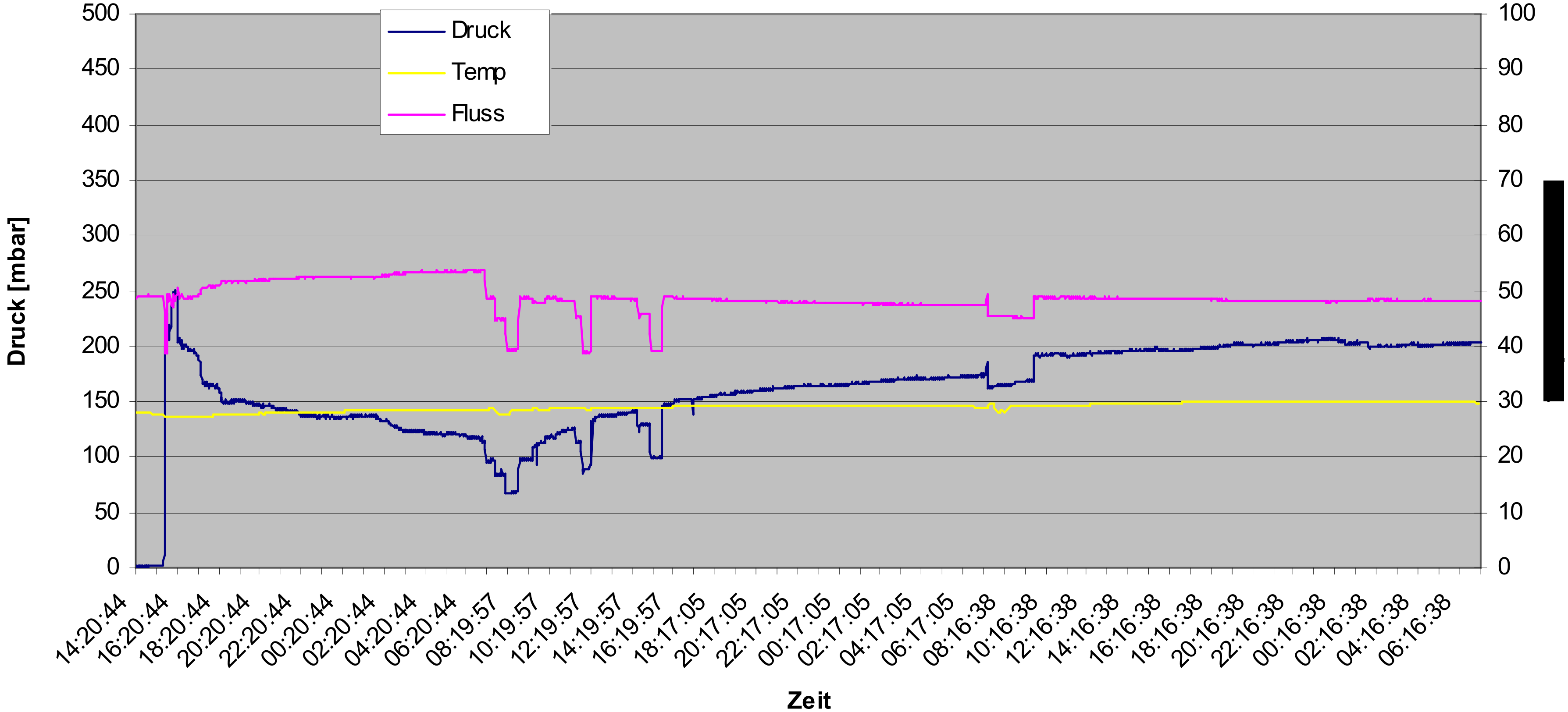
Plant 2 overall head losses for high flow rate



Plant 2 overall head losses for low flow rate



Plant 3 Chemical Testing Results

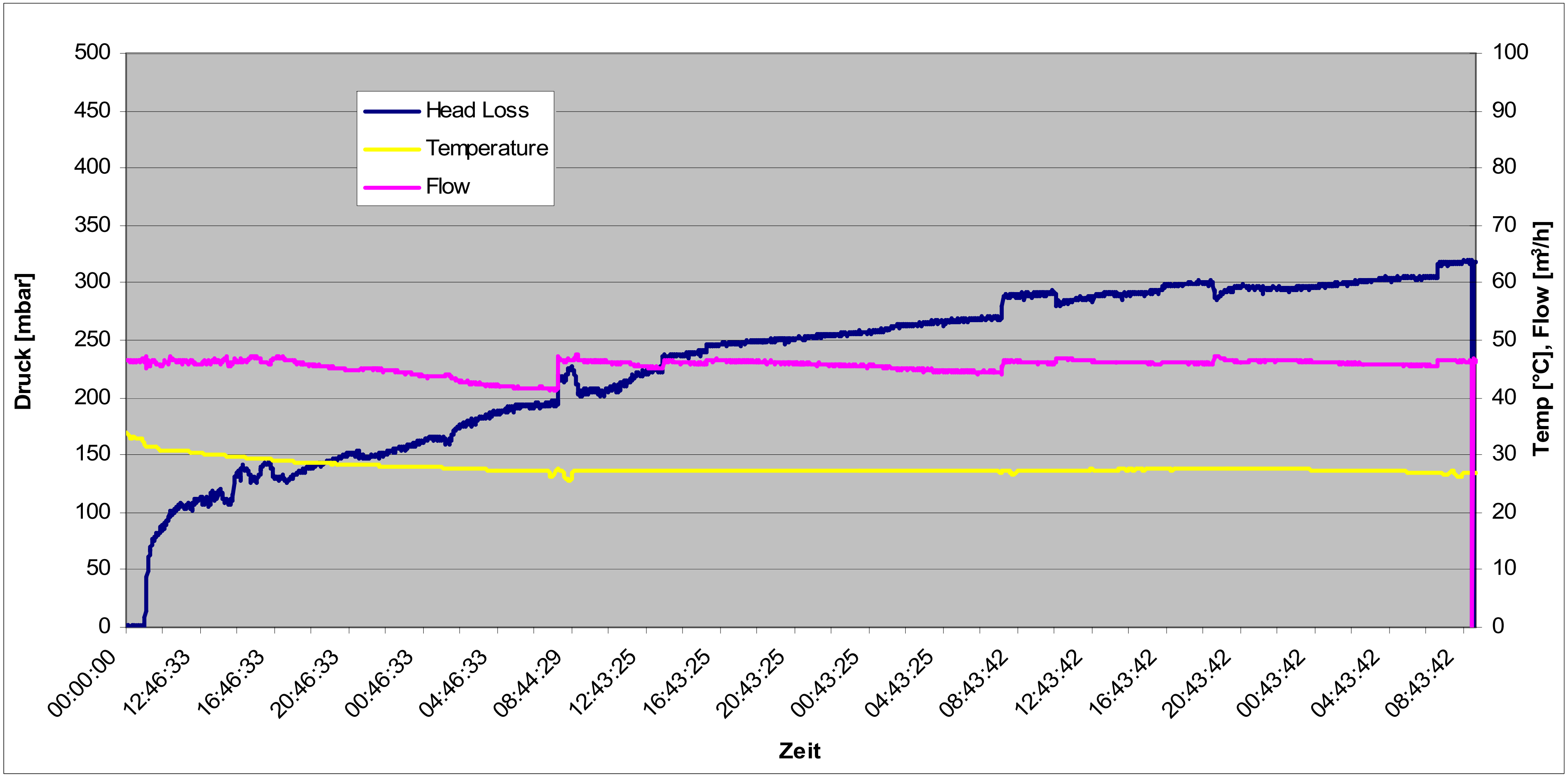


Plant 3 chemical test

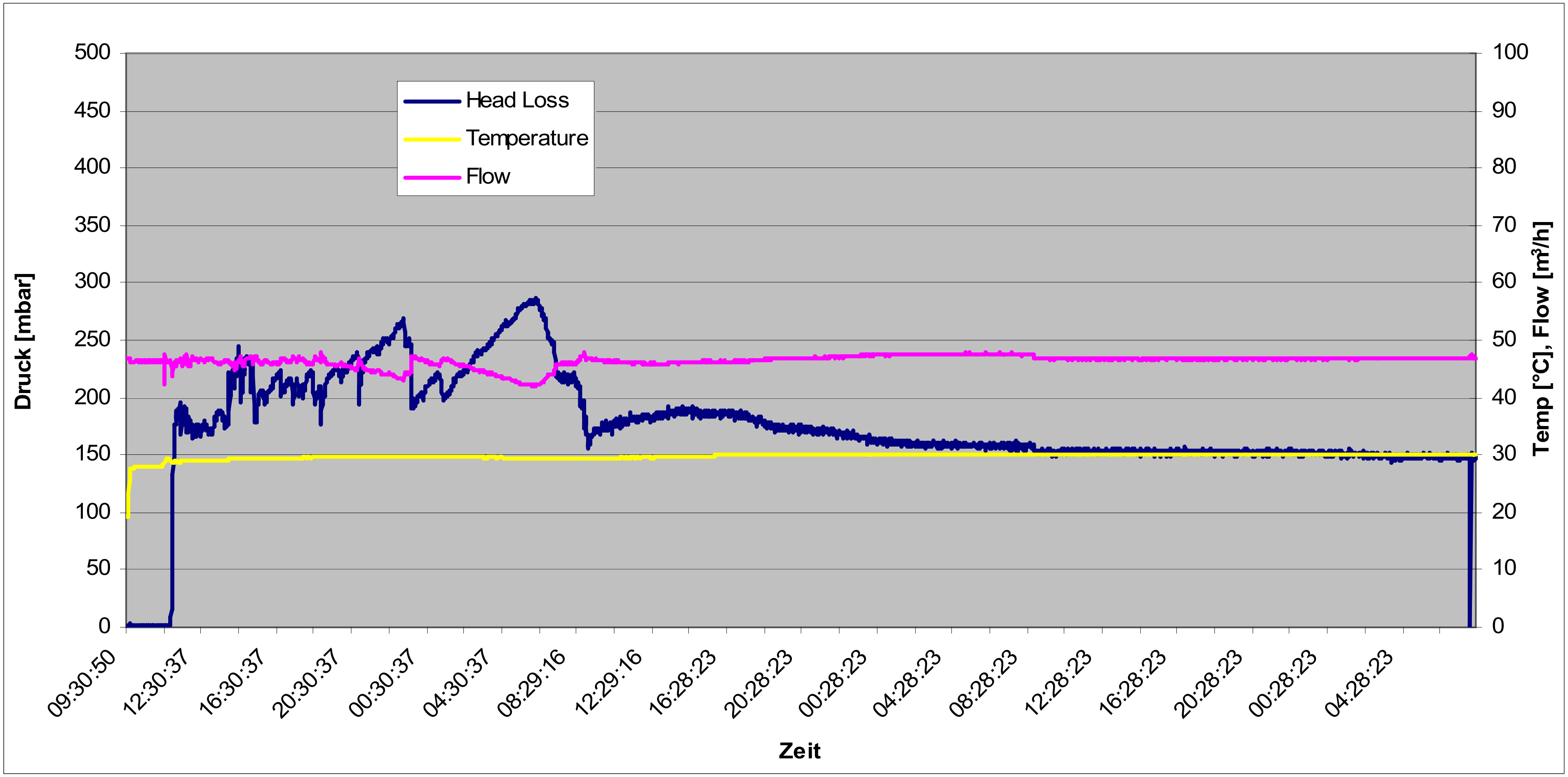
Plant 3 chemical test

Plant 3 chemical test

Plant 4 Chemical Test #2



Plant 4 Chemical Test #3



Plant 4 chemical tests

Plant 4 chemical tests

Status CCI chemical testing for USA

- Chemical testing for 4 plants completed, plus for 1 plant partially done
- Chemical testing for 5 plants to be done in 2nd half of 2007
- Final head loss reports follow test reports for each plant