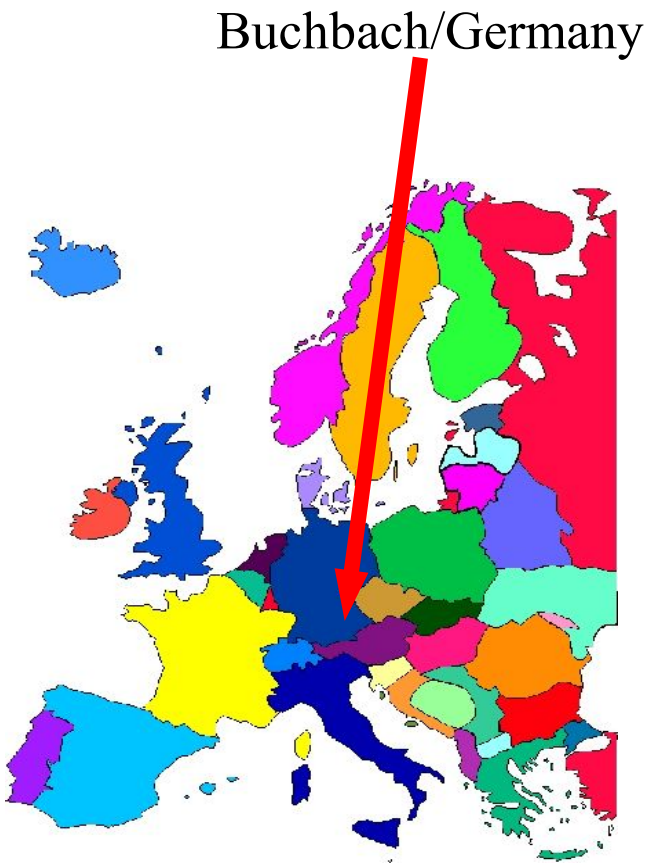
CDF-Presentation

Information
about
Technics
and
Handling
and the
Test Procedures

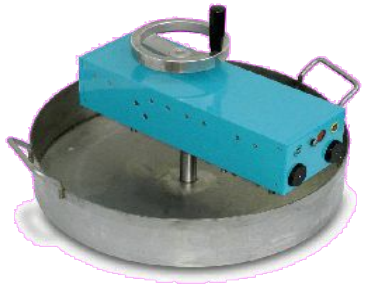
Dipl.-Ing. Oliver Teubert and Dipl.-Ing. Markus Greim

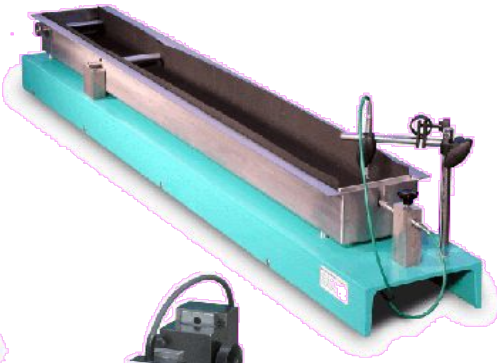
Schleibinger Geräte



30 km east of the
Munich airport

Main Products

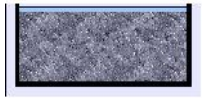
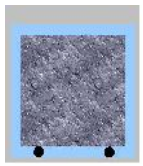




- CDF- and Slab-Tester
- Viscometers
- Shrinkage testing equipment
- Maturity Measurement
- AKR/ASR and Special Applications

Main European Freeze Tests

Freeze Thaw Test for Concrete (EN 12390 and others)

Method	Equipment	Principle	Duration	Investment	Original Cost	Precicion
Slab-Test			56/28 Days	>15.000 €	51 € per specimen 204 €	--
Cube-Test			56 Days	>40.000€	45 € per 2 specimen 90 €	-
CDF-Test			14 Days	>40.000€	34 € per specimen 170 €	++

CDF

Capilary suction of

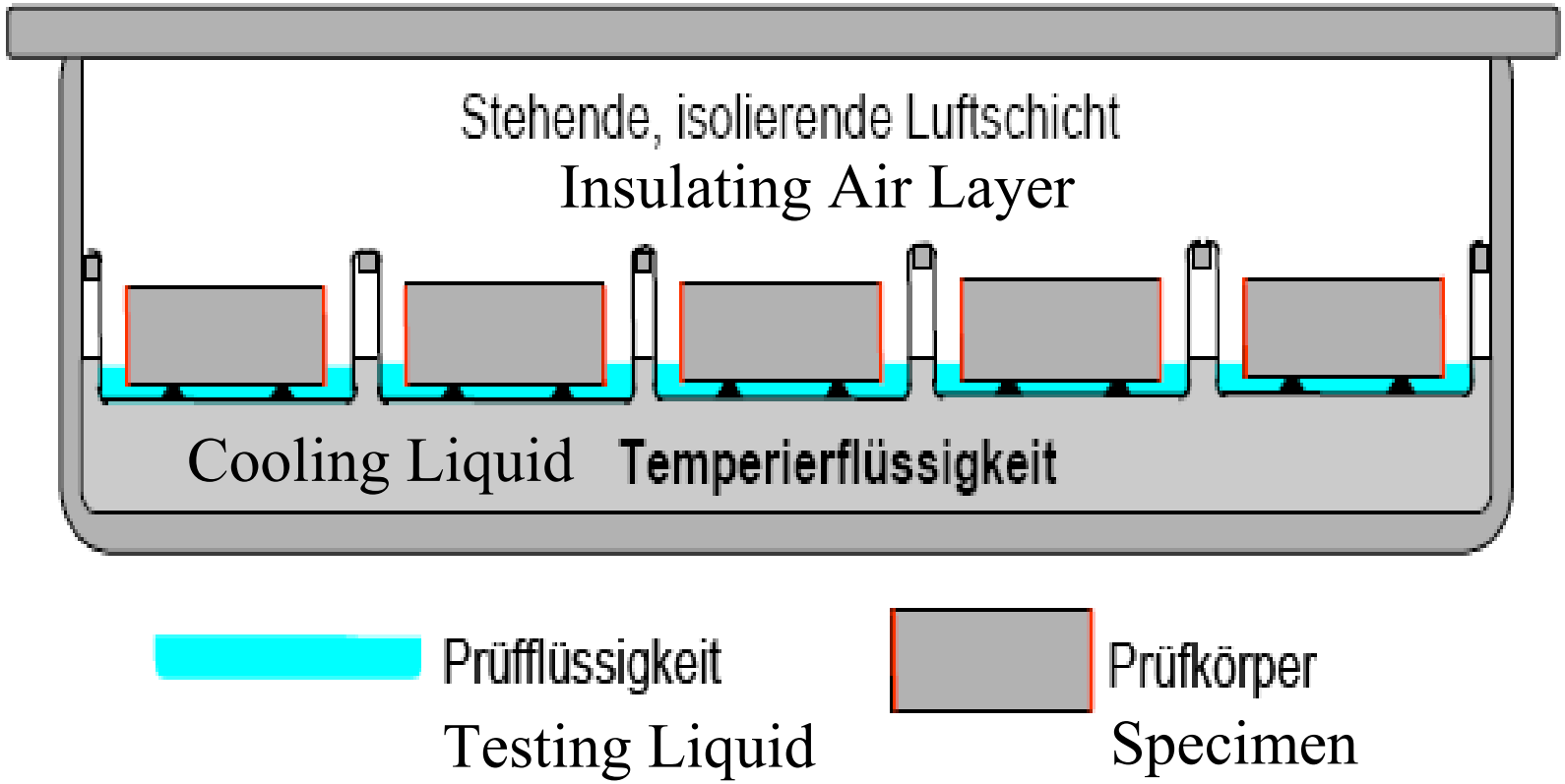
De-icing solution and

Freeze

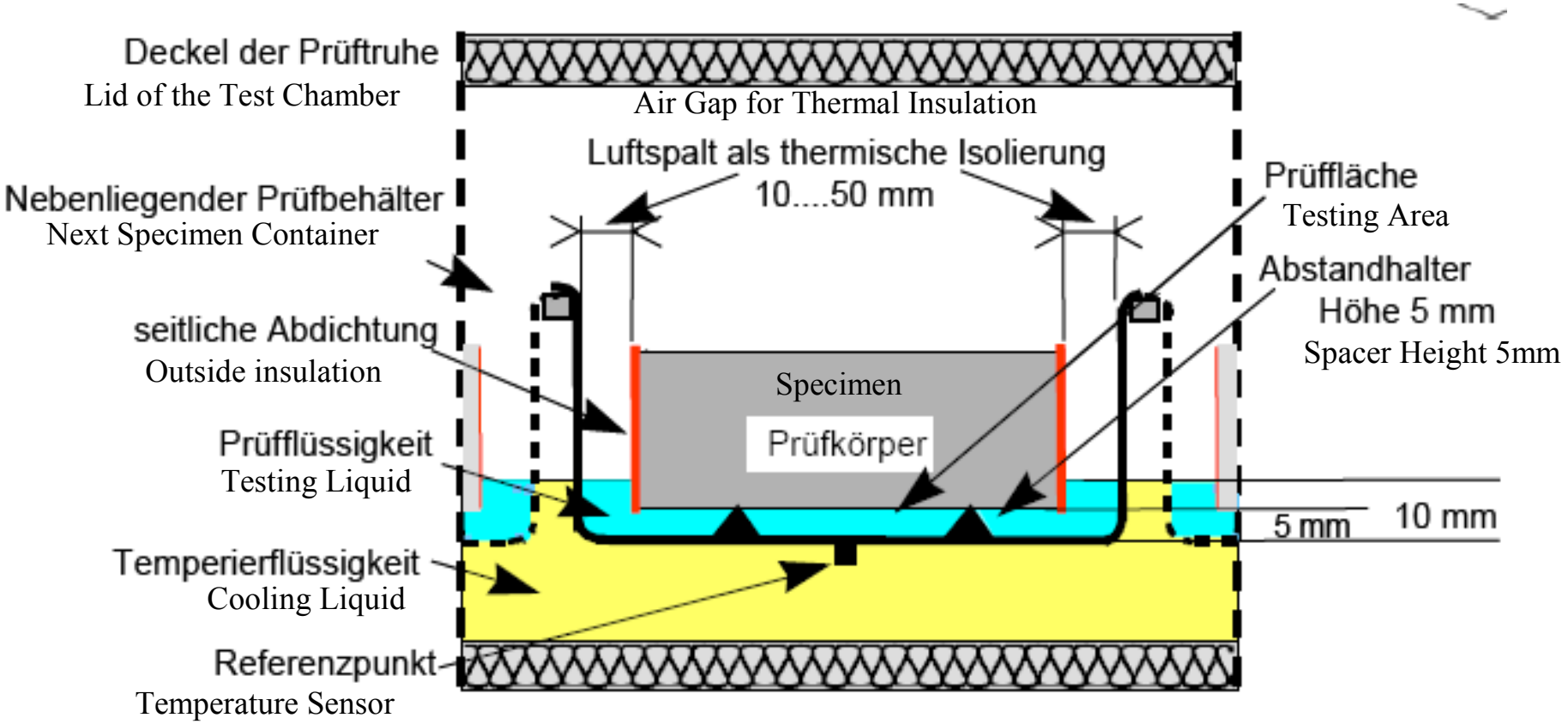
The CDF Standard(s)

- RILEM TC 117-DC: Freeze Thaw and Deicing Resistance of Concrete - CDF Test – Test method for the freeze-thaw resistance of concrete – test with sodium chloride solution (CDF) – prepared by Setzer, Fagerlund and Janssen, 1996
- DD CEN/TS (prEN) 1290-9:2006 – Testing hardened concrete – Part 9: Freeze-thaw resistance – Scaling
- German Hydraulic Research Institute, Karlsruhe, Frosttests for Concrete, 2004 (in German)
- Other National Standards

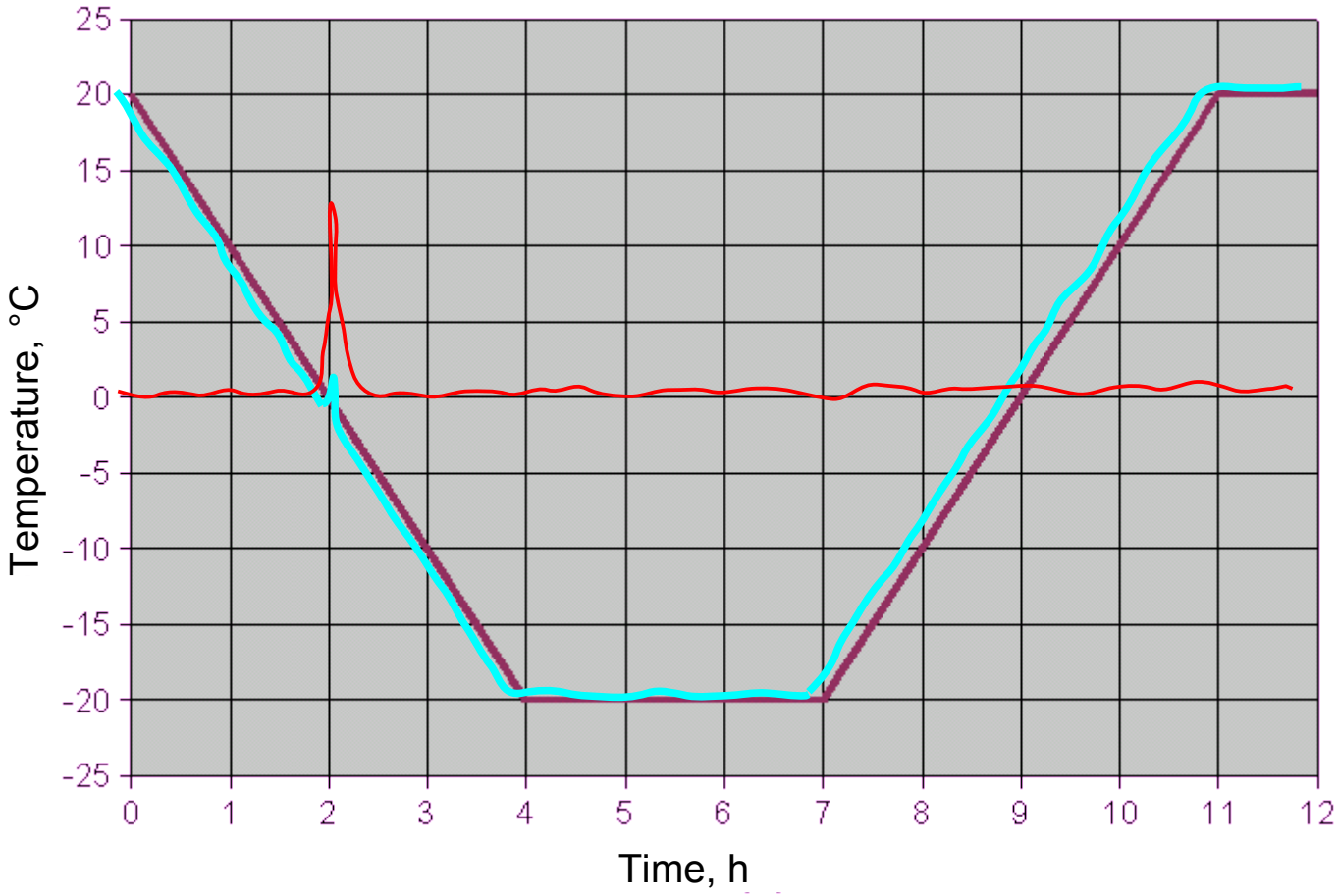
CDF Basic Principle



CDF Bascic Principle II

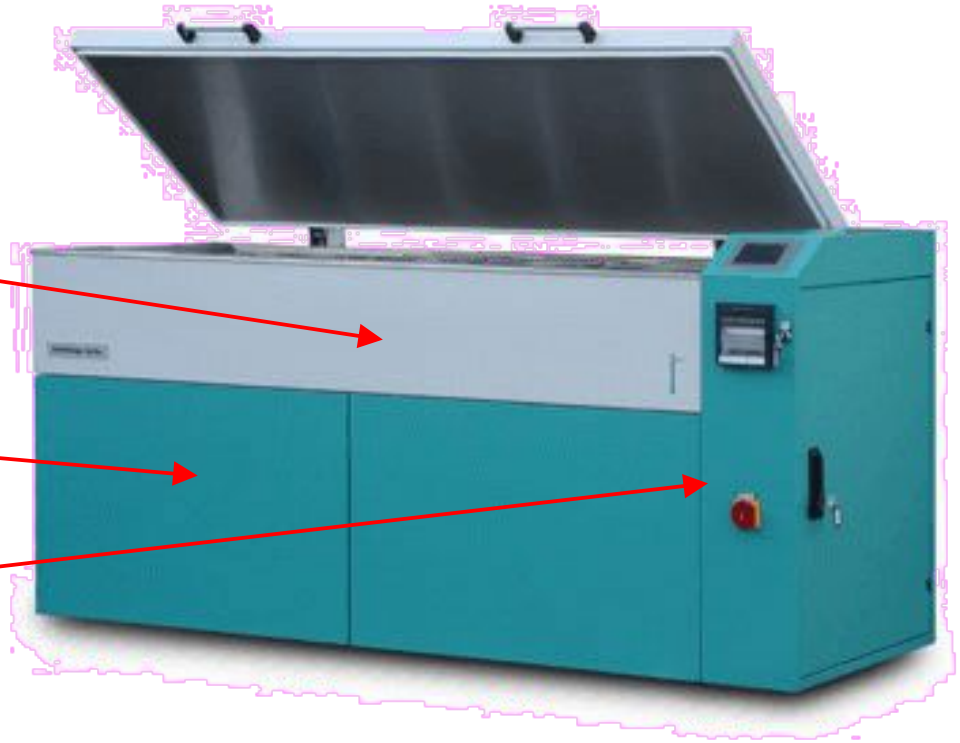


Temperature Program

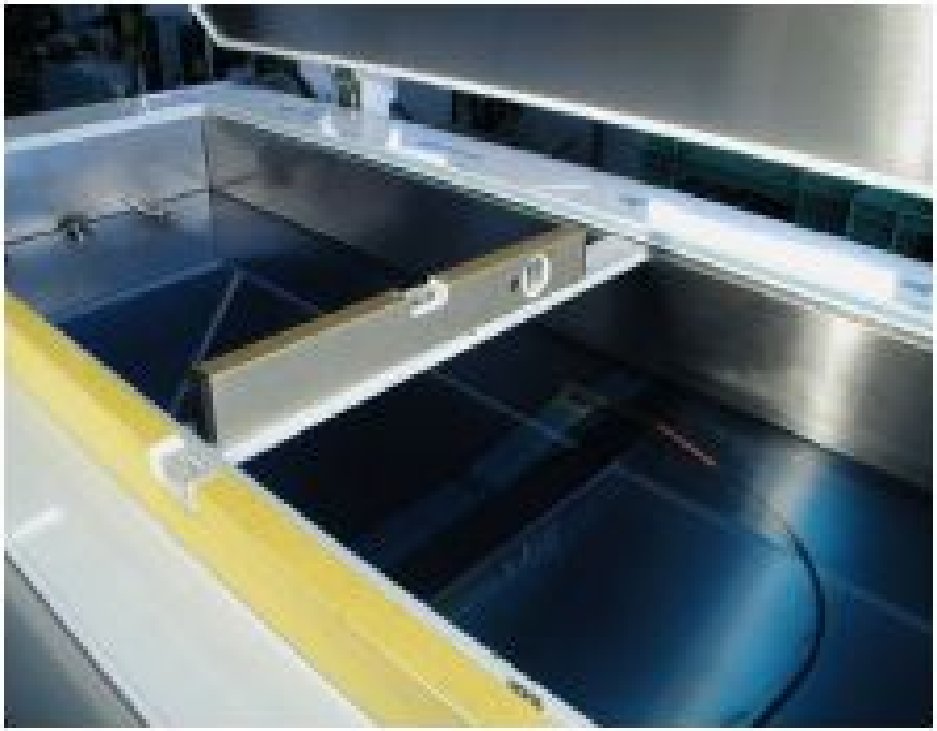


Construction of CDF-equipment

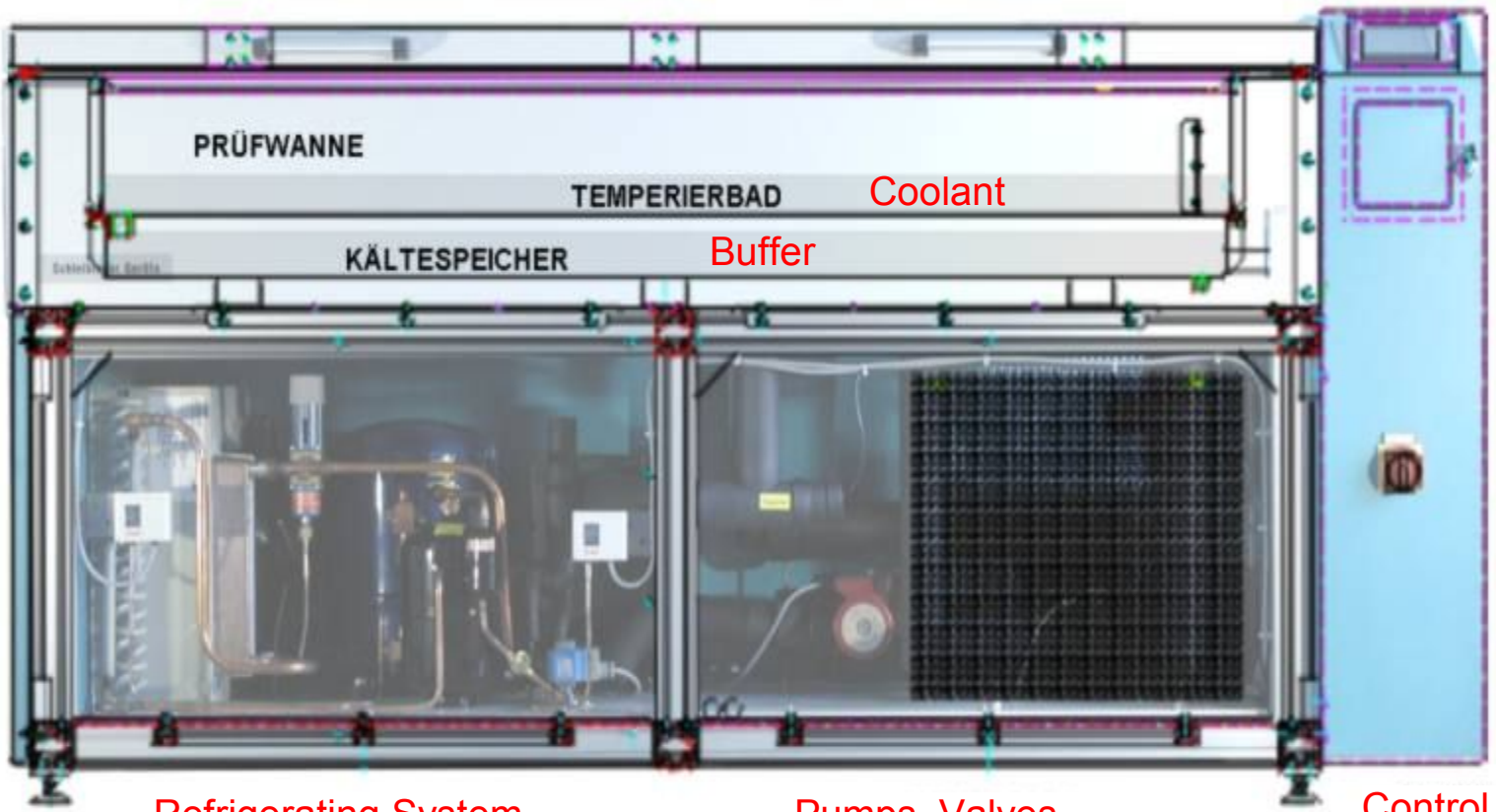
- Bath and Buffer
- Aggregates
- Elektronic



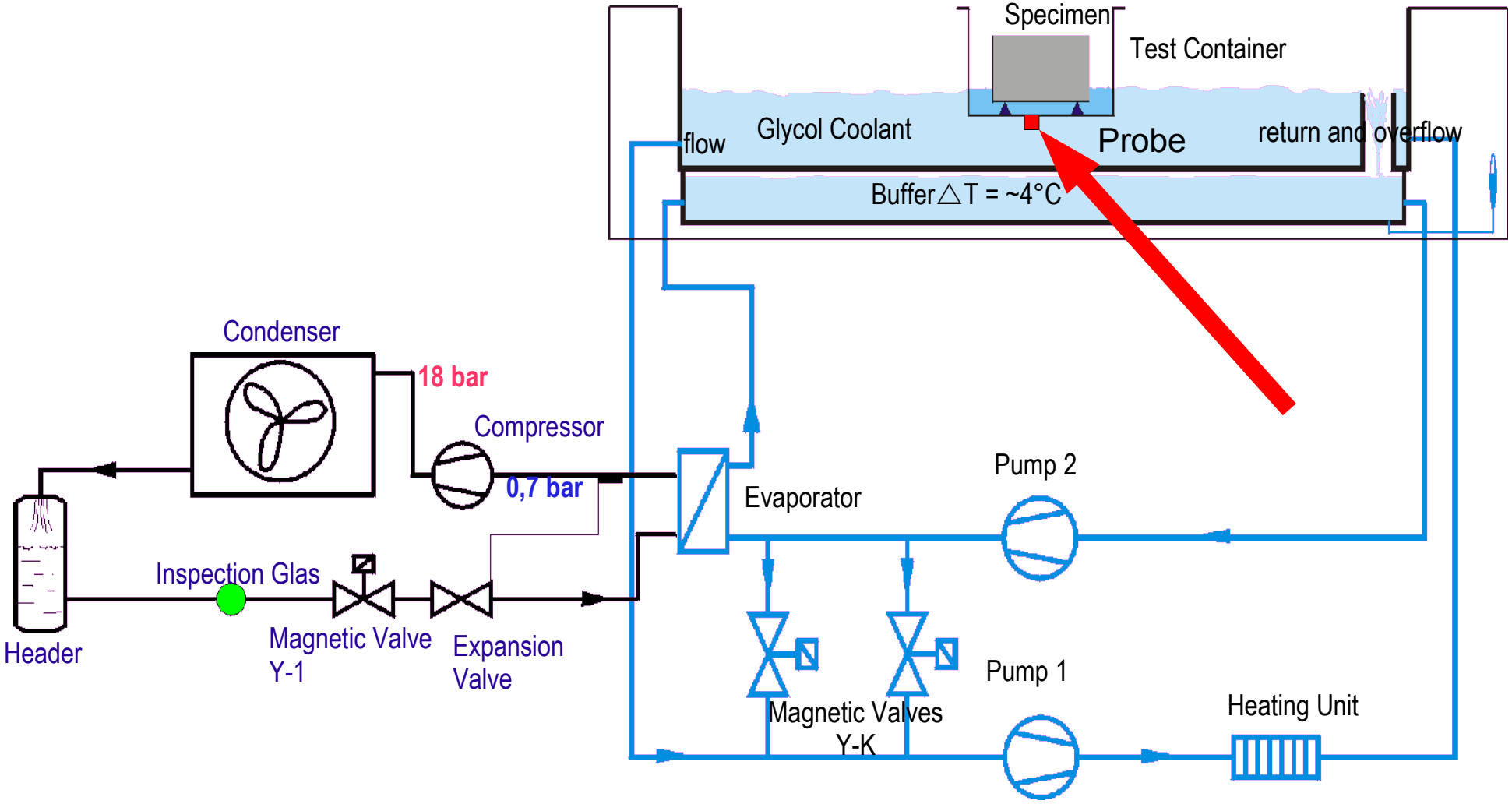
TheCooling Bath



Arrangement of Aggregates



Schematic Diagram



CDF

Capilary suction of

De-icing solution and

Freeze

Equipment I

- Equipment for making 150 mm concrete cubes according to EN 12390-2.
- PTFE plate (Polytetrafluorethylene)
- Climate controlled chambe, temperature of (20 ± 2) °C, evaporation of (45 ± 15)g/(m² h) (= wind velocity < 0,1 m/s, rel. humidity of (65 ± 5) %. The evaporation is measured from a bowl with a depth of approximately 40 mm and a cross section area of (225 ± 25)cm2. The bowl is filled up to (10 ± 1) mm from the brim.
- Lateral sealing
- Freezing medium, consisting either of 97 % by mass of tap water and 3 % by mass of NaCl (for test with de-icing salt) or of de-ionised water only (for test without de-icing salt).
- Unit for adjusting liquid level, i. e. by suction device.

Equipment II

- Test containers, stainless steel.
- Spacer (5 ± 0,1mm)

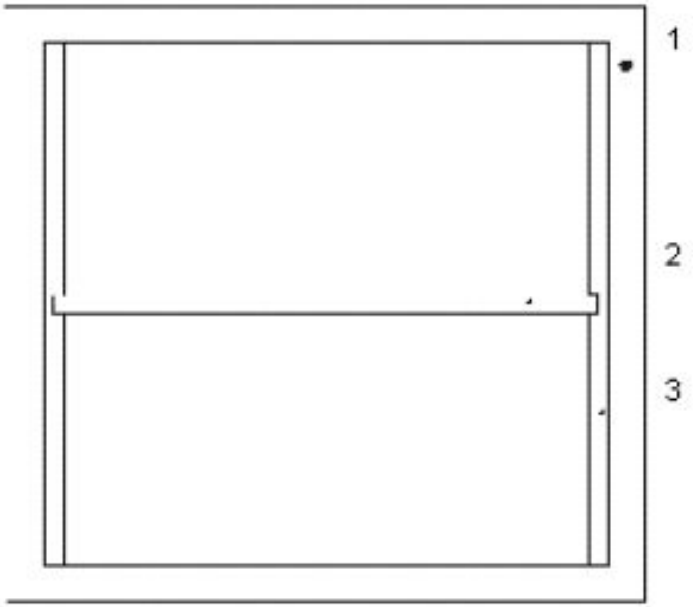
- Temperature controlled chest
- A temperature gauge with an accuracy of ± 0,05 K at 0 °C
- Ultrasonic bath. The test container does not have a mechanical contact to the ultrasonic bath. The minimum distance between the test container and the lower surface of the bath amounts to 15 mm.
- Suitable paper filter
- Drying cabinet, controlled at a temperature of (110 ± 10) °C.
- Balance, with an accuracy within ± 0,05 g.
- Vernier callipers, with an accuracy within ± 0,1 mm.

Preperation of the Specimen

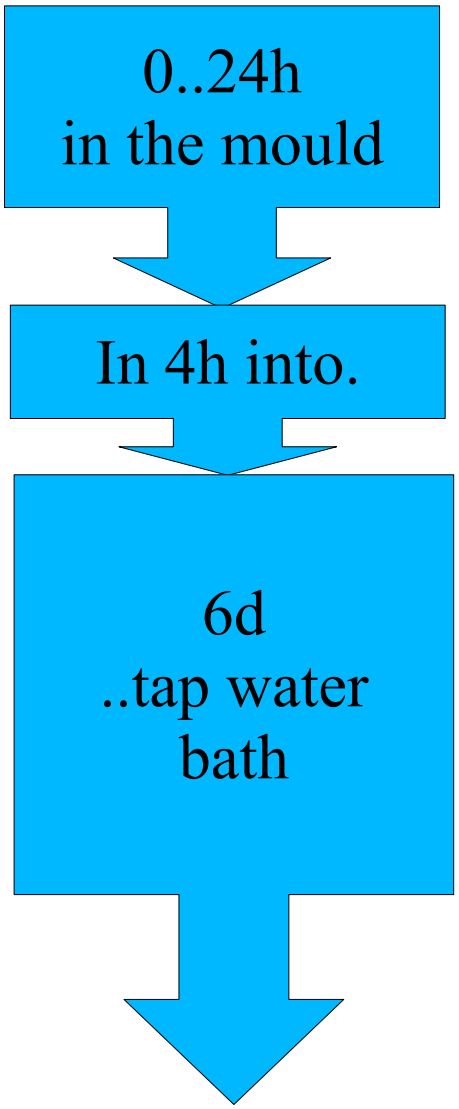
The test requires five specimens. The test surface of each specimen is approx. 140 mm x 150 mm.

The PTFE plate is centred in the mould in order to divide the mould into halves. The vertical PTFE plate serves as a mould surface. The centred plate can be fixed by two other plates which are placed vertically. The concrete surface at the PTFE plate is the test surface. The PTFE plate is not treated with any demoulding agent

IIt is permissible to insert two PTFE plates at two opposed vertical sides. In this case, the specimens are cut through the centre between the two test surfaces after storage under water. For larger aggregate size the PTFE plate can be placed only at one side of the mould.



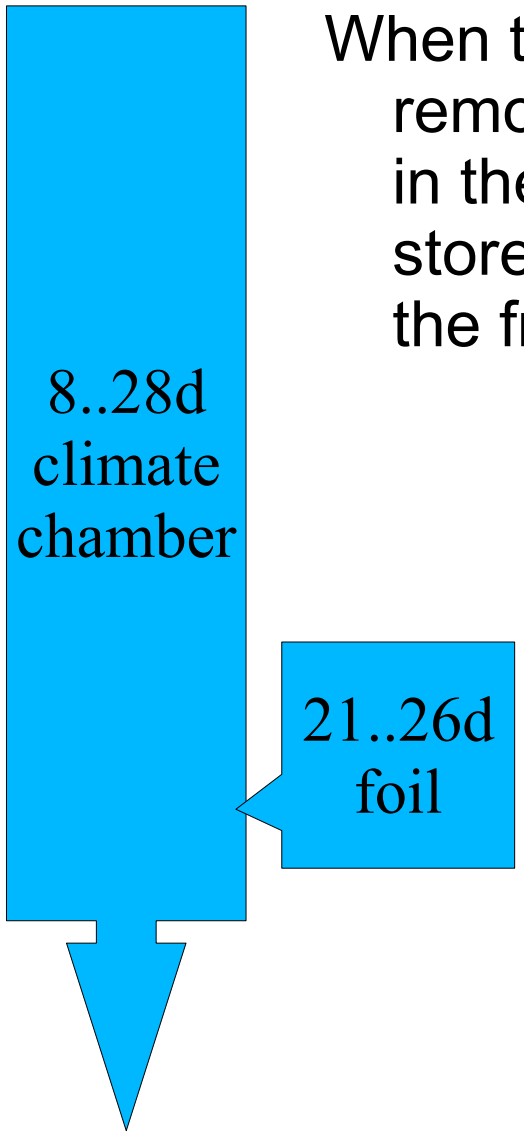
Specimen Preparing [1..7[d



During the first day after casting the cubes are stored in the moulds and protected against drying by use of a polyethylene sheet. The air temperature is (20 ± 2) °C.

After (24 ± 2) h, the cubes are removed from the moulds and placed for 6 days in a bath with tap water having a temperature of (20 ± 2) °C.

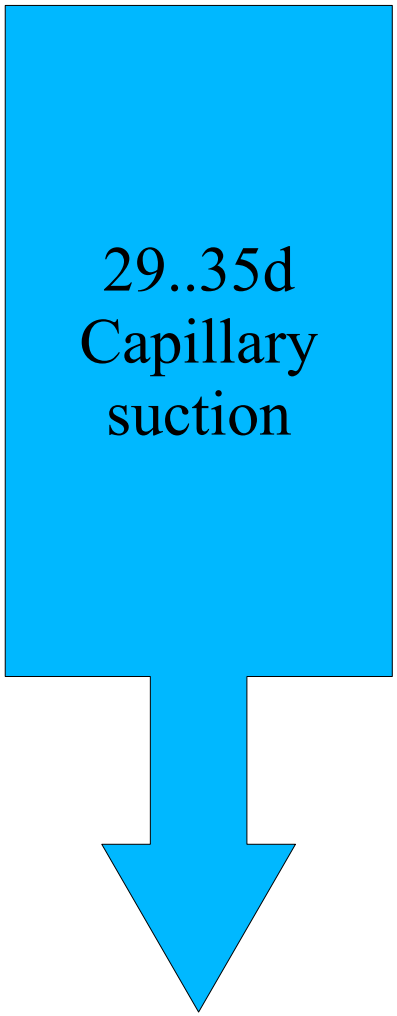
Specimen Preparing [8..28[d



When the cubes are 7 days old they are removed from the water bath and placed in the climate chamber where they are stored for surface drying for 21 days until the freeze-thaw testing starts.

Between 21st and 26th day after casting the specimens the lateral surfaces are either covered with aluminium foil glued with butyl rubber or sealed with a solvent-free epoxy resin. Immediately after this treatment the specimens are returned to the climate chamber.

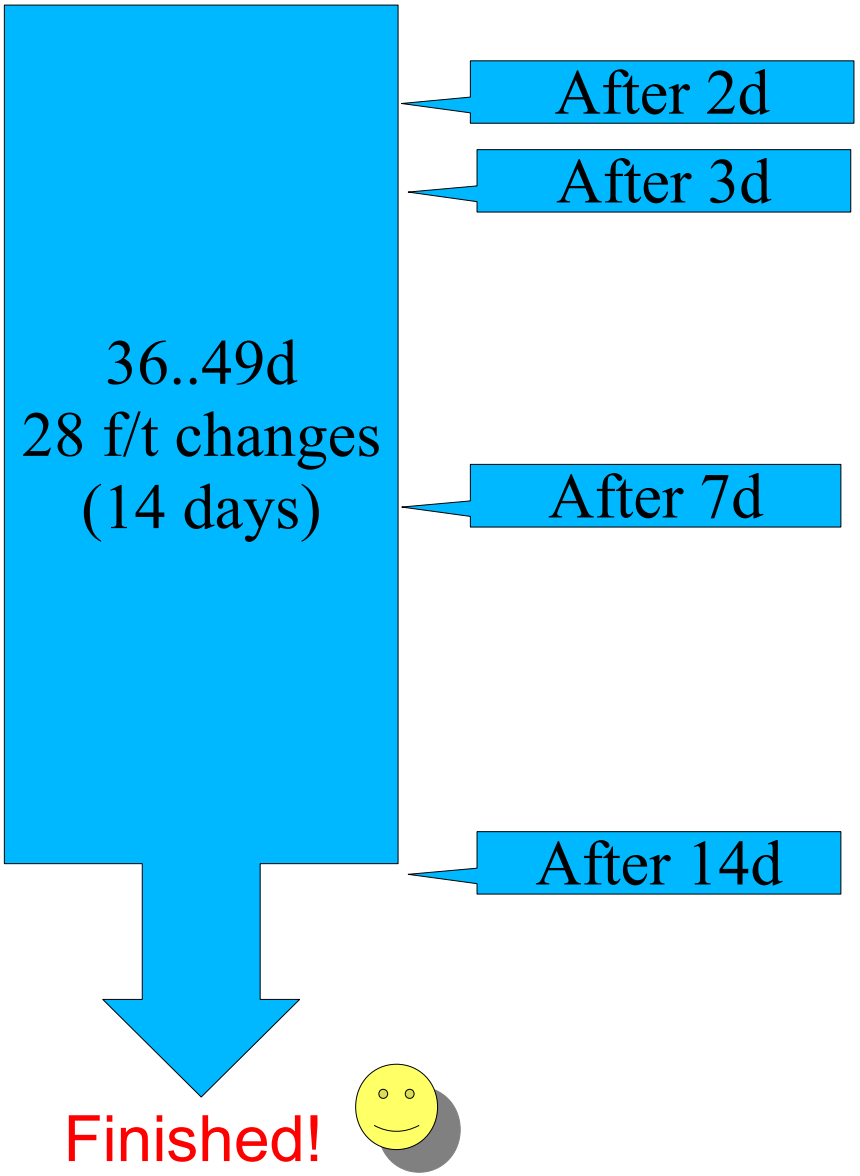
Capillary Suction [29..35[d



The freeze-thaw test starts after 28 days with the resaturation of the specimens. Following dry storage, the specimens are placed in the test containers on the (5 ± 0,1) mm high spacers with the test surface downwards. Subsequently, the freezing medium is poured into the container to a height of (10 ± 1) mm without wetting the specimen's top.

During the capillary suction the test container is closed. The capillary suction period is seven days at a temperature of (20 ± 2) °C. Check and adjust the liquid level above at regular intervals, depending on the suction capacity of the material during capillary suction. The weight gain of the specimens is measured.

CDF Freeze-Thaw Test [36..49[d

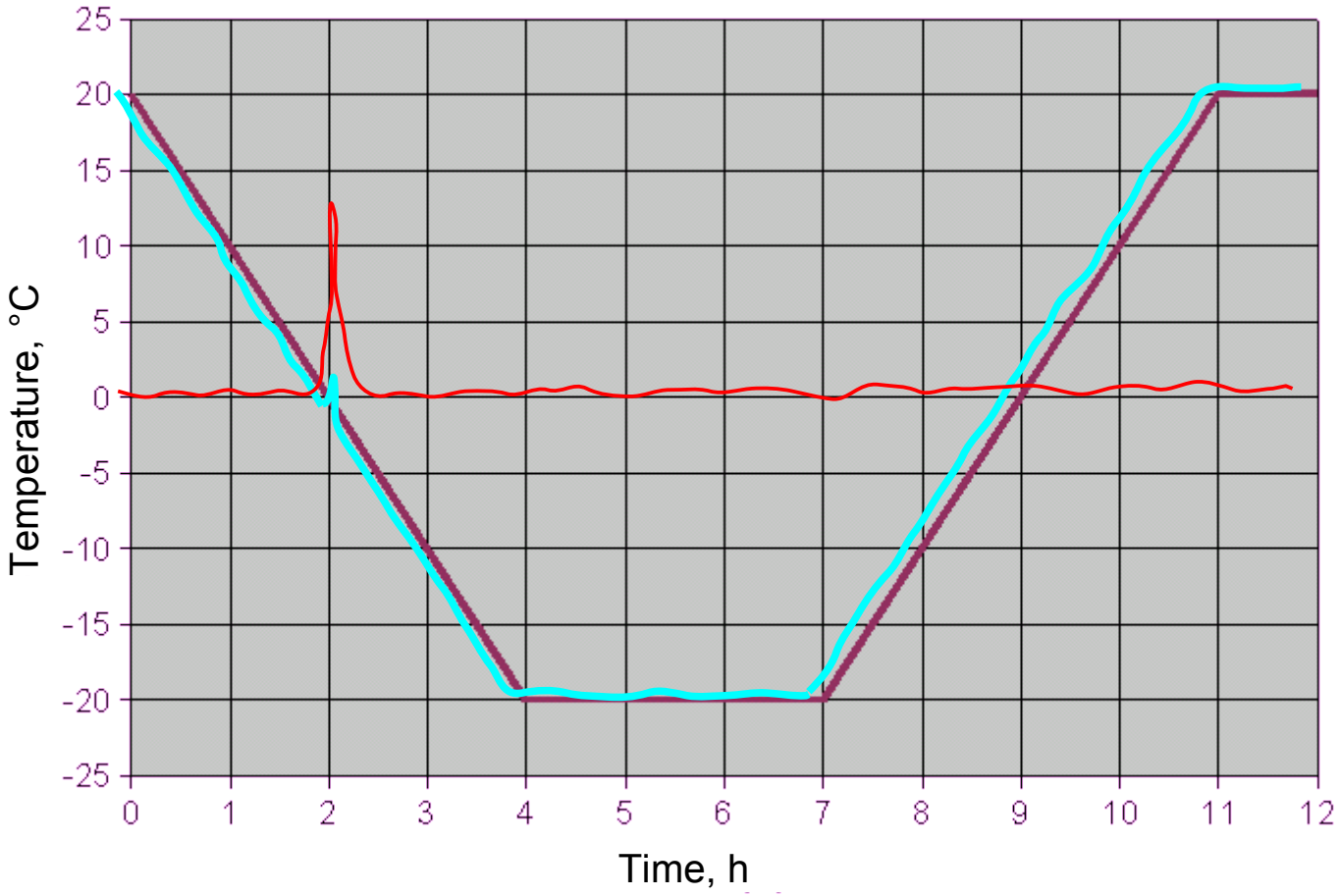


Before starting the freeze-thaw cycles, remove loosely adhering particles and dirt from the test surfaces of the specimens by treatment in the ultrasonic bath.The material removed is discarded.

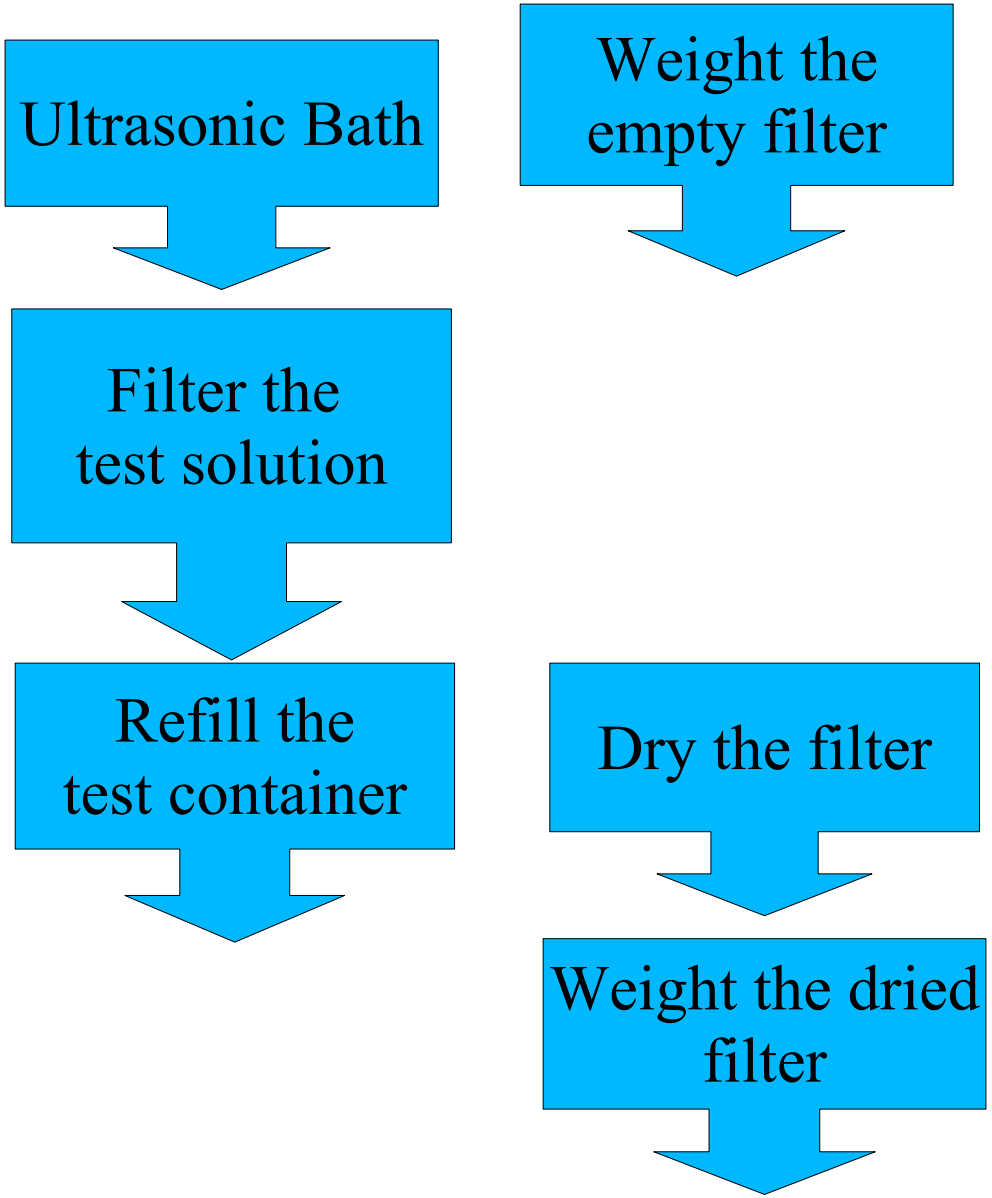
Test procedure after 4±1, 6±1, 14±1and 28 freeze thaw cycles

carry out the following procedure for each specimen while the temperature is above 15 °C.

Temperature Program



The Test Procedure



To remove loosely adhering scaled material from the test surface, the test container is dipped into the contact liquid of an ultrasonic bath and subjected to ultrasonic cleaning for three minutes.

The solution comprising the scaled material is filtered. The suitable paper filter is subsequently dried at (110 ± 10) °C for 24 hours and cooled for (60 ± 5) min at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 5) %. The mass of the filter containing the dried scaled material ms+f is weighed to 0,1 g. The mass of the empty filter mf is determined before with the same accuracy.

Result

The cumulative mass of the dried scaled material ms, n is determined by:

$$m_{s,n} = m_{s,before} + (m_{s+f} - m_{f}) \ [g]$$

For each measurement and each specimen calculate Sn, the cumulative amount of scaled material per unit area after n cycles, in kilograms per square metre:

$$S_{,n} = (m_{s,n}[g] / A[mm^2]) * 1000 \quad [kg/m^2]$$

$S_{,n}$ is the mass of scaled material related to the test surface after the n-th cycle in kg/m^2,
$m_{s,n}$ is the cumulative mass of dried scaled material after n freeze-thaw cycle, A is the test surface in mm^2, calculated on the basis of the linear dimensions as the average of at least two measurements determined to the nearest 0,5 mm.

Test Report

- Reference to this Technical Specification;
- origin, size and marking of the specimens;
- concrete identification;
- the composition of the freezing medium;
- amount of cumulative scaled material for each specimen as well as the mean value and the standard deviation in kilograms per square metre rounded to the nearest 0,001 kg/m²,
after (4 ± 1), (6 ± 1), (14 ± 1) and 28 cycles;
- visual assessment (cracks, scaling from aggregate particles) before the start and after (4 ± 1), (6 ± 1), (14 ± 1) and 28 cycles
- any deviations from this alternative test procedure;
- *optional*: Mass of solution sucked up during the capillary suction period for each specimen as well as the mean value and the standard deviation;
- *optional*: The composition of the concrete.

CF Test

- The CF test is the CDF test without De-icing agent so:
- The freezing medium is de-ionised water only
- The number of frost cycles is 56 = 28 days
- The test procedure is done after : (14 ± 1), (28 ± 1), (42 ± 1) and 56 freeze thaw cycles

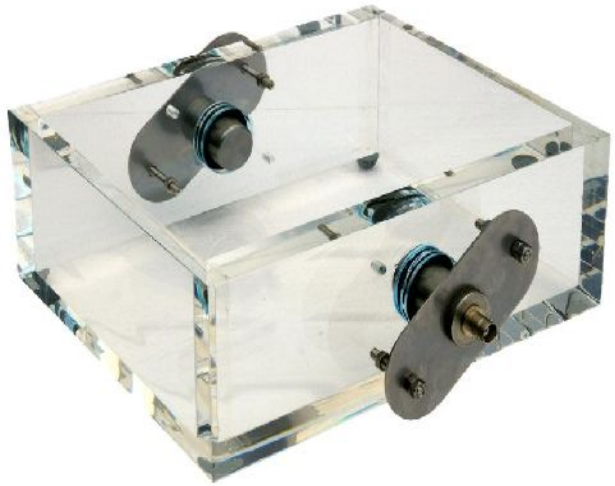
CIF Test

Capillary Suction, **I***nternal damage* and **F**reeze-thaw Test

It's an extension of the CDF test

Additional equippment:

- Test container for ultrasonic transit time measurement
- Calibration test specimen is used for calibration of the ultrasonic transit time measurement. Dimensions 150 x 110 x 70 mm
- Specimen carrier as particle collector



Other differnces to the CDF test

- Height of he specimen 70mm±2mm
- After storage under water the specimen are cut on the rough top side to 110 mm, if 2 PTFE plates are used the specimen are vertically divided.
- The mass of the specimen during drying has to be monitored
- Test at 0, and every 4^{th} or 6^{th} cycle

The additional test procedures

1. Surface scaling (as CDF)

2. Moisture uptake

Set the specimen with he test surface on a towel
Dry all other surface
Place the specimen carrier on the a balance
Place the specimen on the specimen carrier

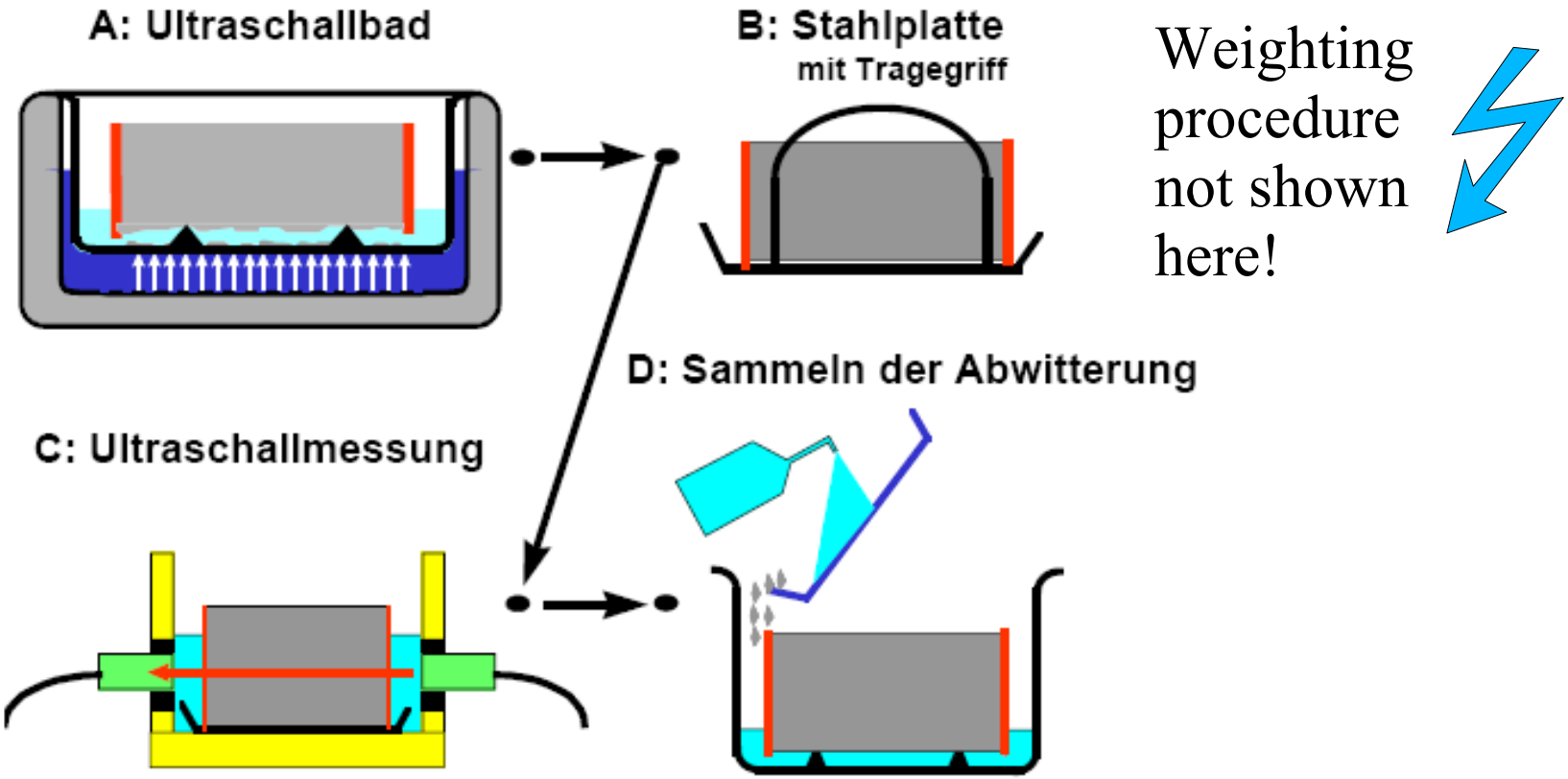
3. Internal damage

Fill the test container 10mm over transducers withh test liquid
Measure the transit time w/o specimen and with
the specimen in both directions.

CIF Test of Scaling and Inner Damage

A: Ultrasonic Scaling

B: Specimen Handling



C: Ultrasonic Transition Time loss for inner Damage

D: Collecting the Scaled Material

CIF Damage Criterion

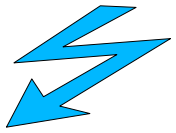
The specimen is damaged when the quadrat of the change of transit time during the test is less 80%

$Ru,n = (t\_0 / t\_n)^2$

t_0 = transit time in the specimen at the beginning
t_n = transit time in the specimen after n cycles

Before the test the interested parties must agree how many cycles the specimen should withstand the damge criterion.

So the number of ycles s not fixed!



How to run failure-free

- Check the freeze protection all two month
- Check the cooling water in summer or open the window
- Check the liquid level of the coolant
- Record the temperatures
- Don´t use wipes of paper
- Make a test run after a long stop

Finally...

- More information at
  www.schleibinger.com

Temperature Calibration

Calibrated thermometer better then 0.1K

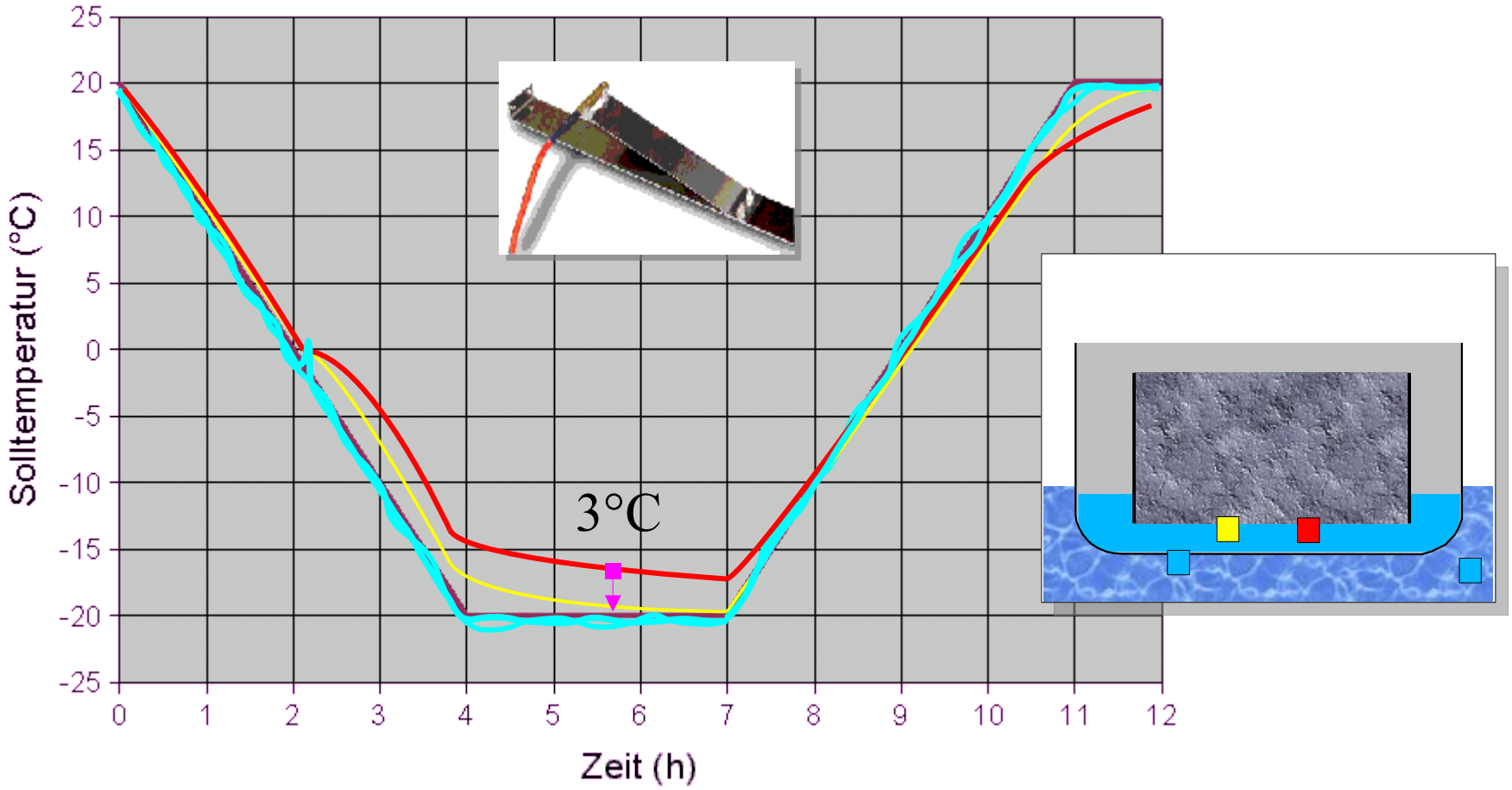
Insulted can with fluid

Take the reference sensor out of he bath

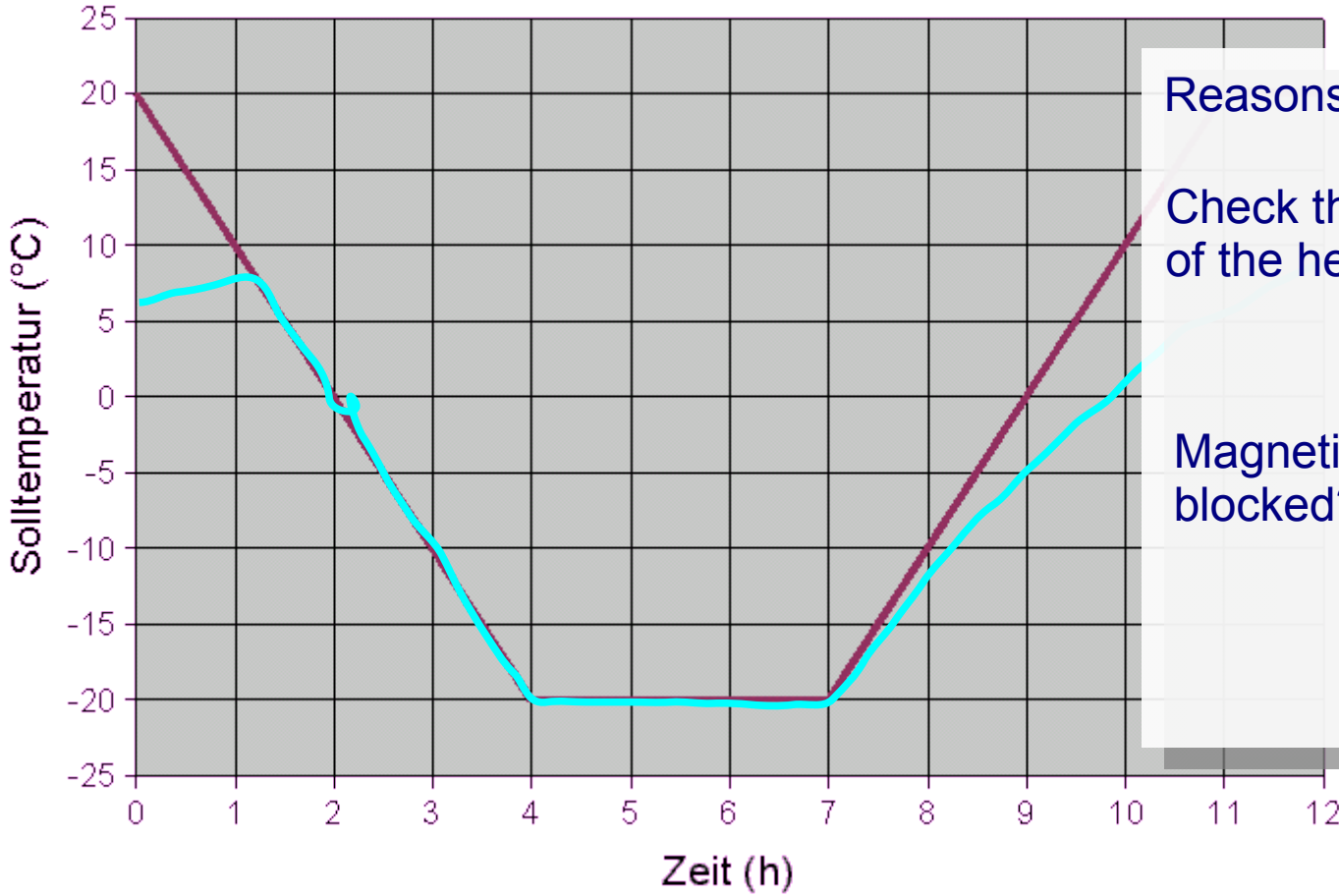
Please check the temperature deviation

The temperature accuracy is the sum of the measurement accuracy abd the accuracy of the controler.
Please always record the system temperature during the test

Sensor Not in the Right Position?



Less heating power?

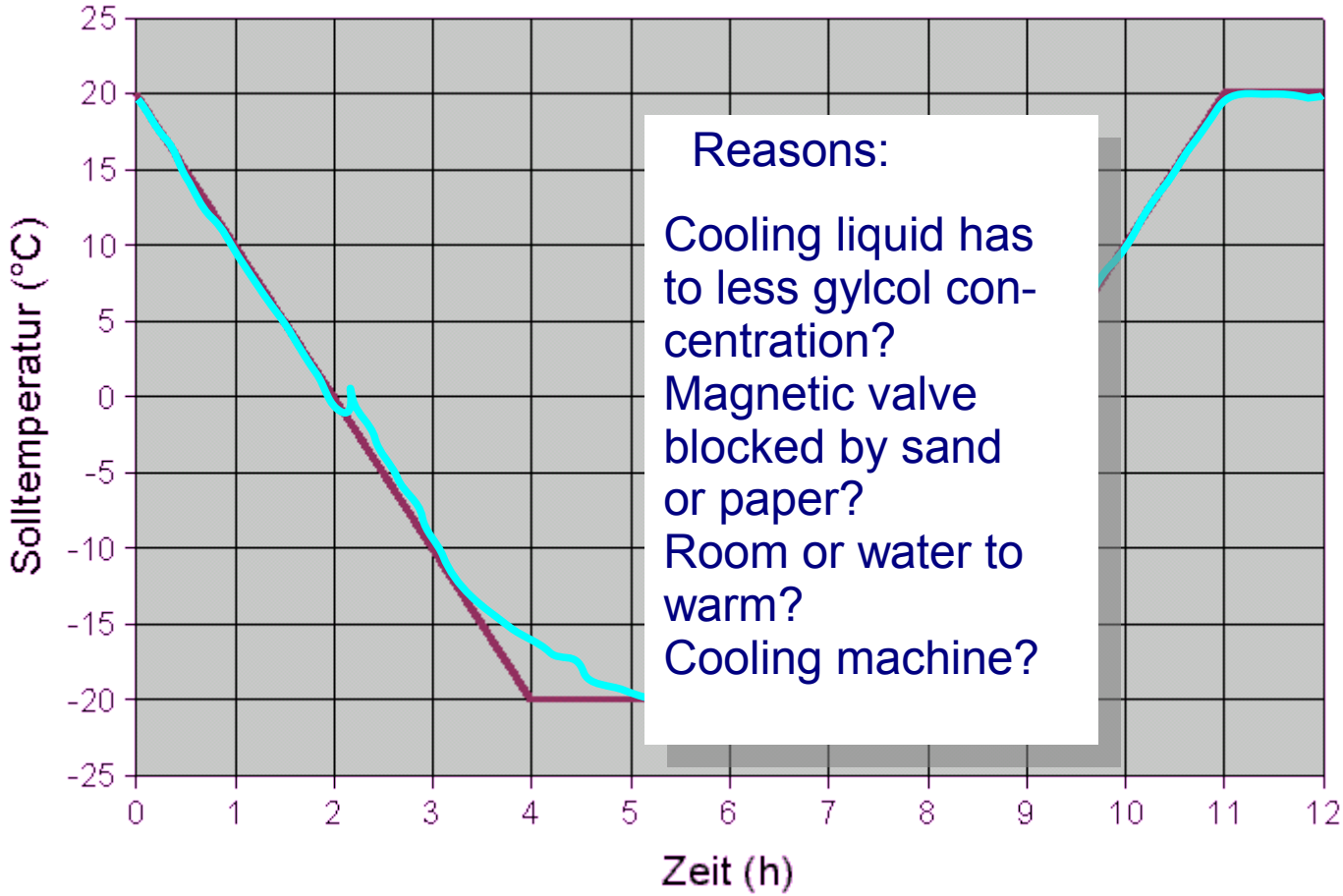


Reasons:

Check the fuses of the heating unit.

Magnetic valve blocked?

Not enough cooling power?



Reasons:

Cooling liquid has to less gylcol con-centration?
Magnetic valve blocked by sand or paper?
Room or water to warm?
Cooling machine?

Cause of failure

- Less freeze protection of the coolant
- Too warm, no cooling water
- Paper fibres in the coolant
- Blocked Condenser
- Too much/less coolant

Freeze Protection

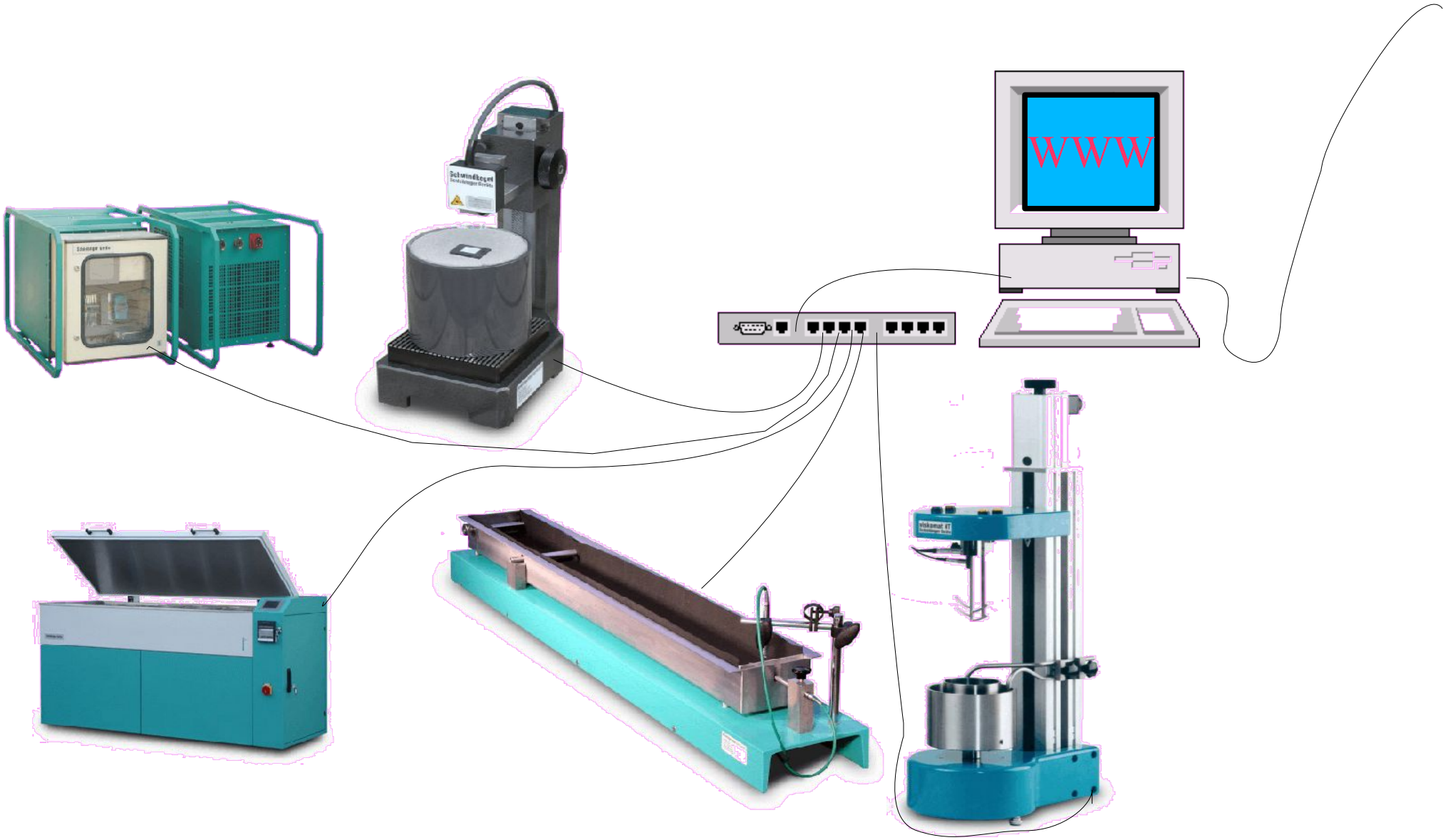
Minimum -45°C oder density 1,078 g/cm³.

Frostschutz Freeze Protection	**Dichte** Density	**Zu ersetzende Menge** Coolant to be replaced
-35 °C	1,070	7 Ltr.
-30 °C	1,065	12 Ltr.
-28 °C	1,060	20 Ltr.
-20 °C	1,050	30 Ltr.

Electronic/Software

Check the calibration data after RAM RESET
or after installing a new software.

All schleibinger equipment comes with Web interface



Finally...

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Schleibinger Wordwide

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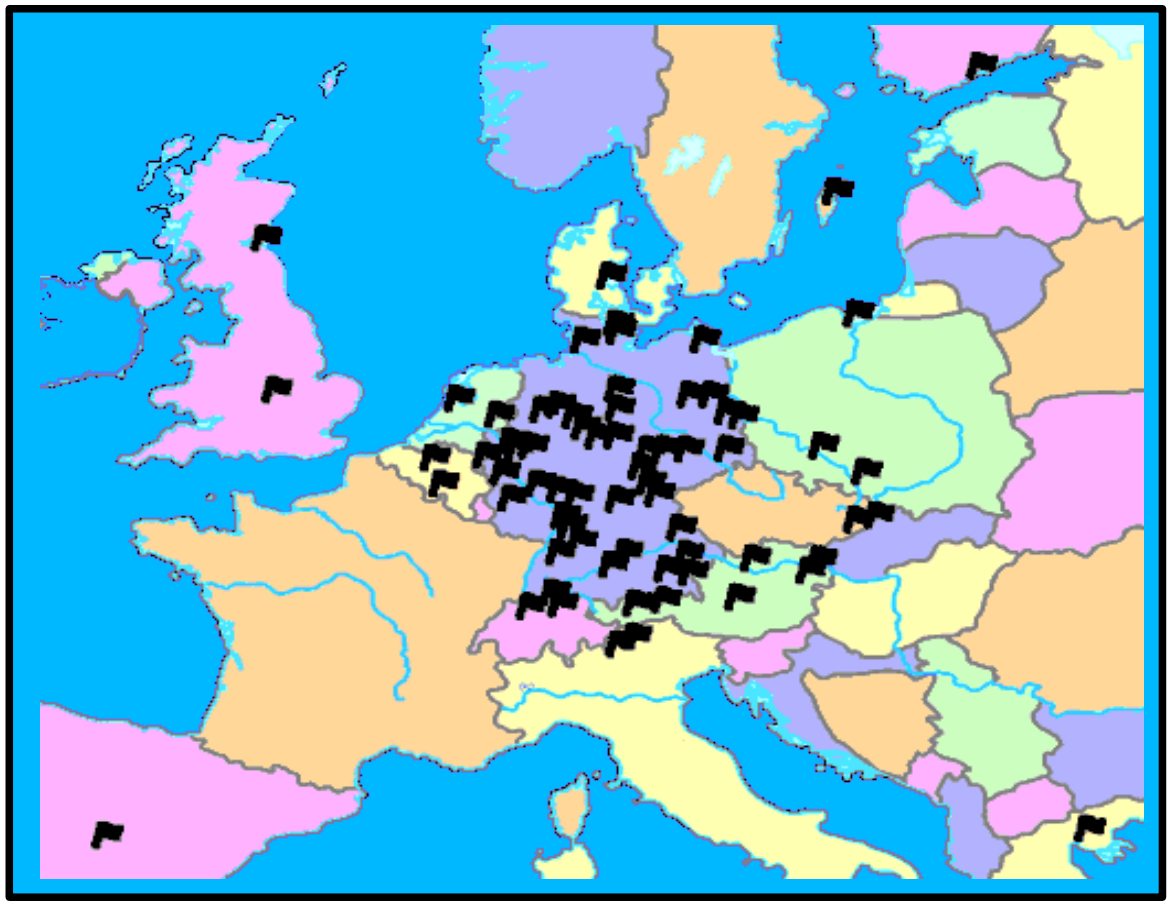
Installations Europe



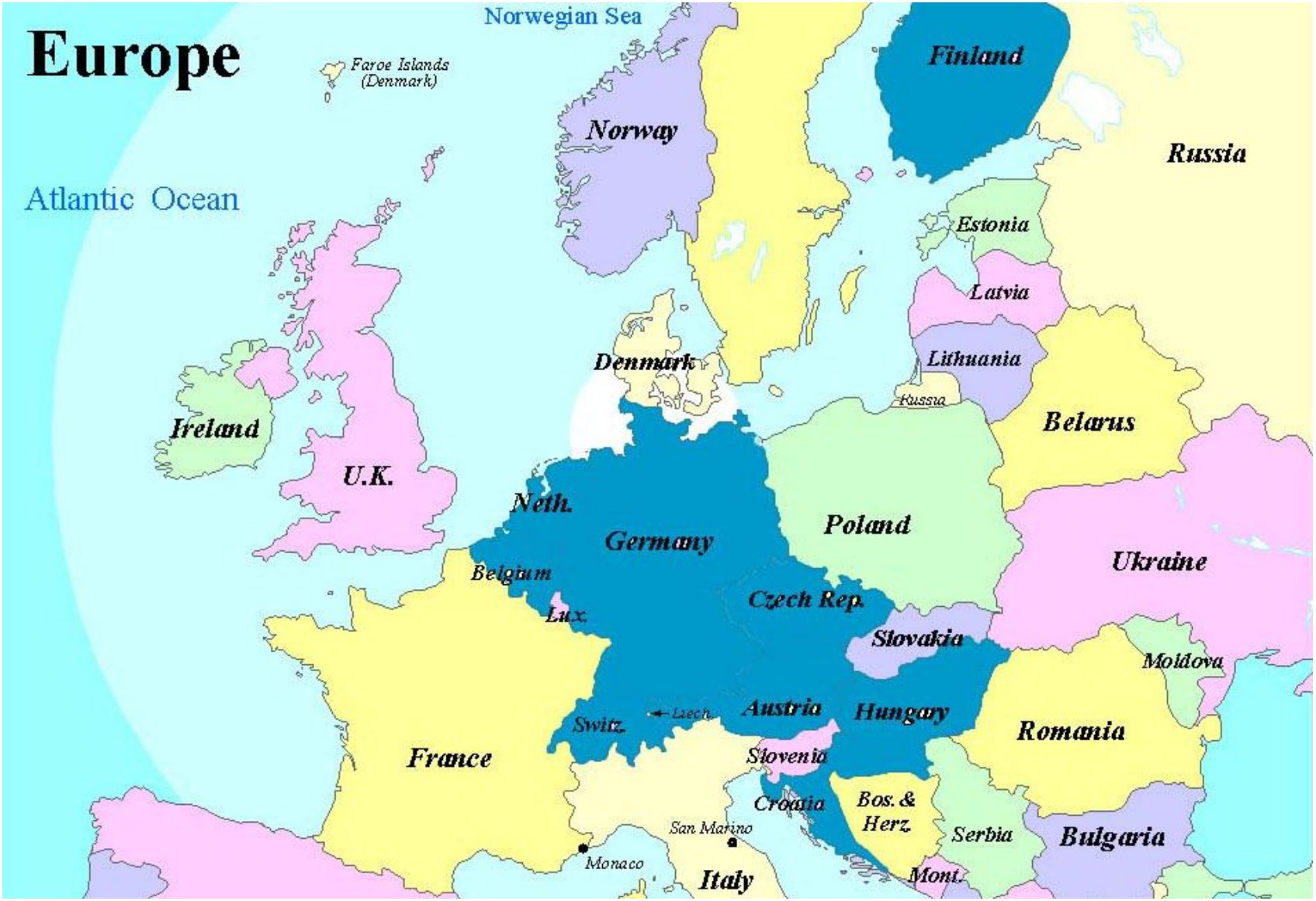
Controller und Programming

- Schleibinger controller and software is fully developed for CDF equipment
- Operating of the equipment by a colour touch screen
- Additional profiles can be programmed by the user
- Data can be uploaded by a optional WEB interface

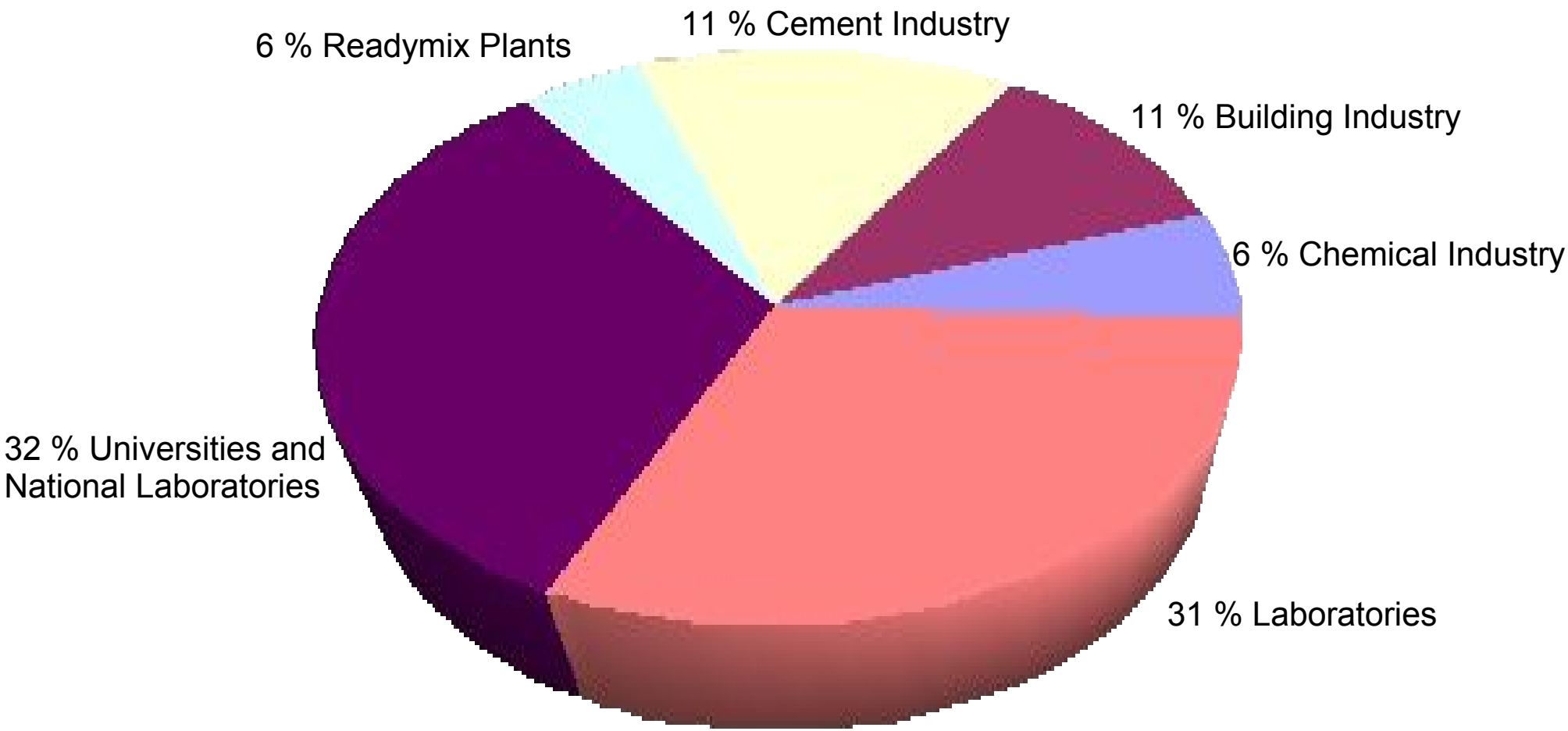
Schleibinger Geräte

- Formation 1990
- New Building and Company Structure 1995
- Two Owners: Greim and Teubert
- 6 Employees
- Annual Sales 750.000 EUR

CDF Customers, Countries



CDF Customers



Decision Support

- Slabtester for casually capacity (low capital cost)
- Cube Test is less expensive, but inprecise
- CDF-Test is quick and accurate

Required Cooling Power

- Max. power is required at the freezing point of the test liquid

- Released energy from 8 kg test liquid is:
  Q = 2 700 kJ = 45 kWmin = 0,75 kWh
- 1,2 kg water must be evaporated to compensate this effect
- or 6 kg refrigerant

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Dear Ladies and Gentlemens
I welcome you to this meeting and thank you for your coming and your interest in the CDF-Test.

Today we have a reverse order of the lectures, so I hope you are not too much confused and can excuse this case.

It was impossible to get a earlier flight for Mr. Prof. Setzer. We are happy for you, that today you will get professional Information about durability of concrete and the CDF-/CIF-test from Prof. Setzer at first hand.

In this lecture, I will give you some Information about the manufacturer Schleibinger, the CDF Market and also some technical information about the equipment.

Schleibinger Geräte

30 km east of the
Munich airport

www.schleibinger.com

Main Products

- CDF- and Slab-Tester
- Viscometers
- Shrinkage testing equipment
- Maturity Measurement
- AKR/ASR and Special Applications

For Freeze thaw test

for workability of fresh concrete, mortar and cement paste

to measure shrinkage and expansion of building materials. It was difficult to develop an equipment for detecting this during the material hardens. The solution was a beaker like a cone and detecting the distance contactless by a laser sensor.

Maturity Tester measures the temperature in the hardened concrete. The strength is a fuction of time and temperature and can be calculated by the measurement datas and a maturity model.

Main European Freeze Tests

Freeze Thaw Test for Concrete (EN 12390 and others)

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Slab-Test			56/28 Days	>15.000 €	51 € per specimen 204 €	--
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CDF-Test			14 Days	>40.000€	34 € per specimen 170 €	++

www.schleibinger.com

To turn upside down

sth requires or takes a week

CDF

Capilary suction of
De-icing solution and
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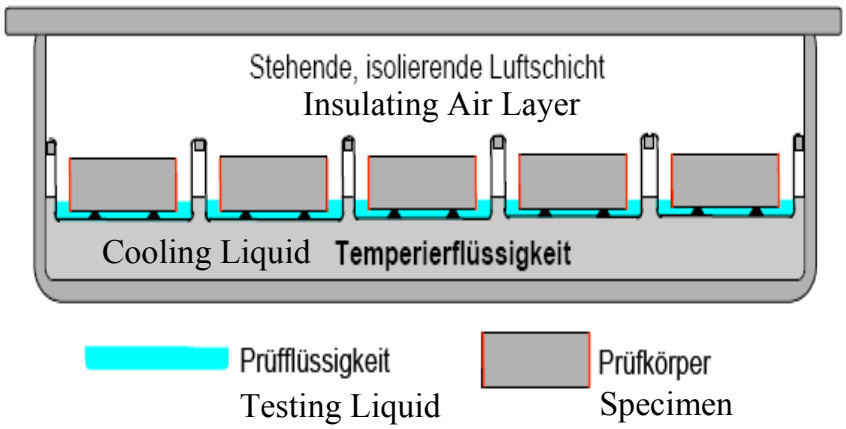
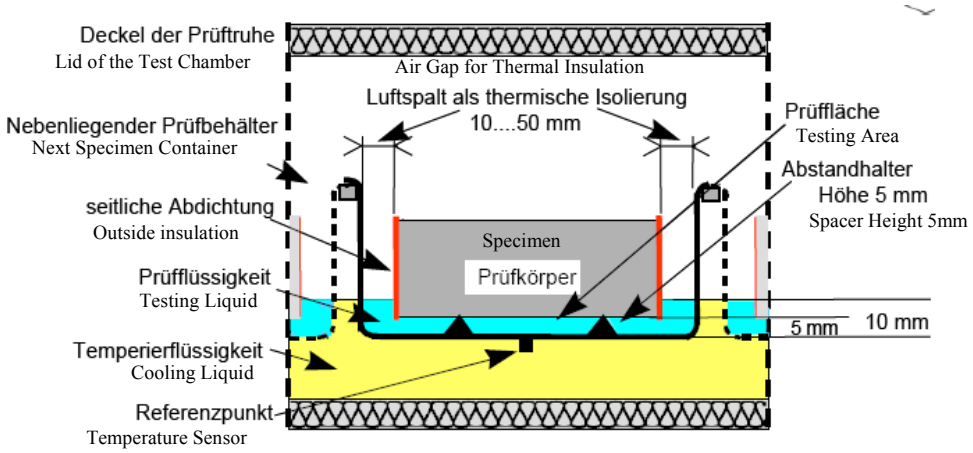
- Other National Standards

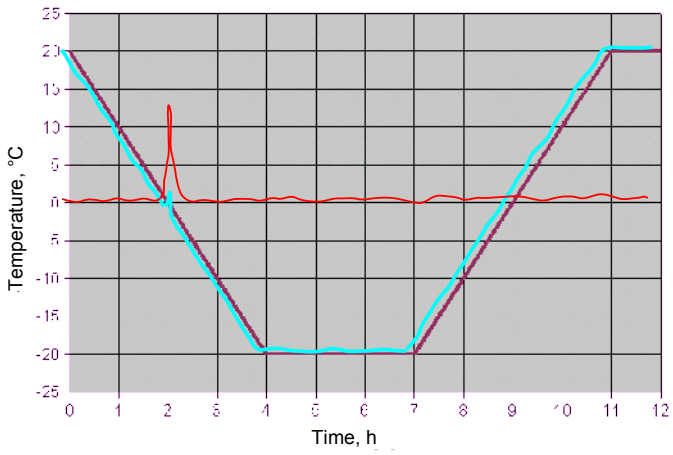
CDF Basic Principle



CDF Bascic Principle II



Temperature Program



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The precision of the temperature measurement is factory calibrated. You find the calibration datas in the documents.

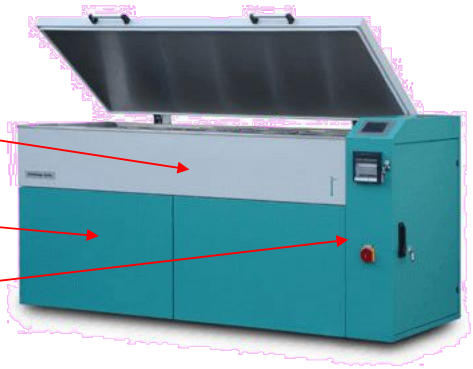
Additional to the deviation of the sensor and the electronic there is the deviation of the controller.

This is the reason why you should keep an eye on the record of the values.

For this use a strip recorder, the display (for the last 24 hours) or the WEB interface,

Construction of CDF-equipment

- Bath and Buffer
- Aggregates
- Elektronic



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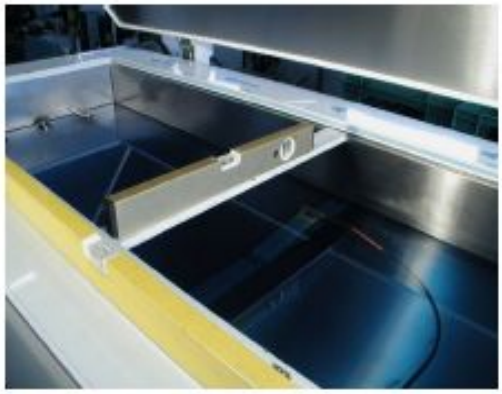
TheCooling Bath



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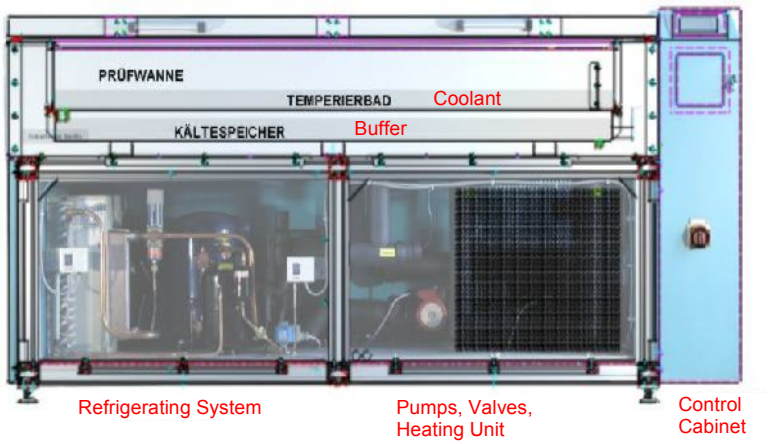
Arrangement of Aggregates



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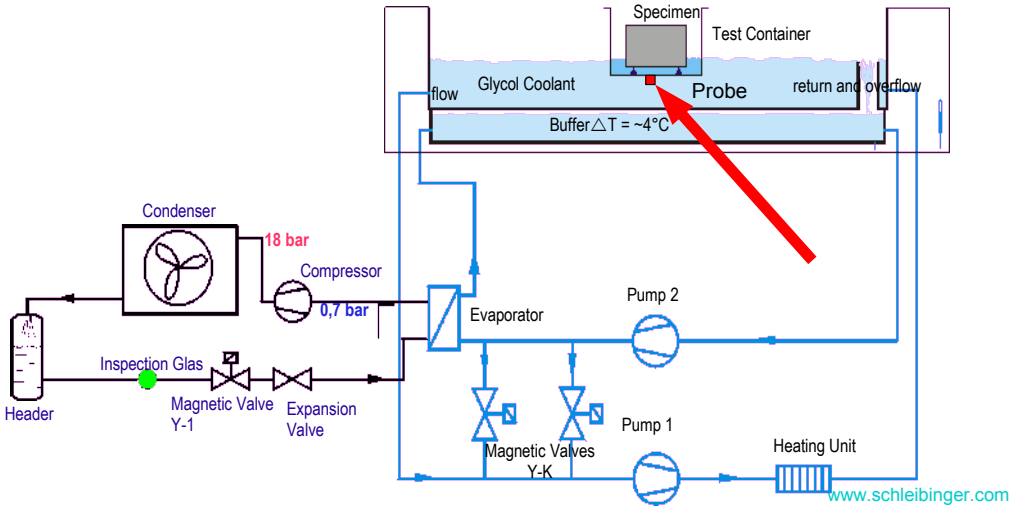
To call so´s attention to sth.

Schematic Diagram



CDF

Capilary suction of
De-icing solution and
Freeze

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Equipment I

- Equipment for making 150 mm concrete cubes according to EN 12390-2.
- PTFE plate (Polytetrafluorethylene)
- Climate controlled chambe, temperature of (20 ± 2) °C, evaporation of (45 ± 15)g/(m² h) (= wind velocity < 0,1 m/s, rel. humidity of (65 ± 5) %. The evaporation is measured from a bowl with a depth of approximately 40 mm and a cross section area of (225 ± 25)cm2. The bowl is filled up to (10 ± 1) mm from the brim.
- Lateral sealing
- Freezing medium, consisting either of 97 % by mass of tap water and 3 % by mass of NaCl (for test with de-icing salt) or of de-ionised water only (for test without de-icing salt).
- Unit for adjusting liquid level, i. e. by suction device.

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Equipment II

- Test containers, stainless steel.
- Spacer (5 ± 0,1mm)

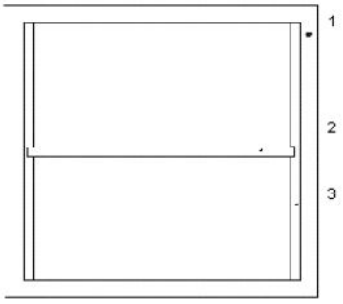
- Temperature controlled chest
- A temperature gauge with an accuracy of ± 0,05 K at 0 °C
- Ultrasonic bath. The test container does not have a mechanical contact to the ultrasonic bath. The minimum distance between the test container and the lower surface of the bath amounts to 15 mm.
- Suitable paper filter
- Drying cabinet, controlled at a temperature of (110 ± 10) °C.
- Balance, with an accuracy within ± 0,05 g.
- Vernier callipers, with an accuracy within ± 0,1 mm.

Preperation of the Specimen

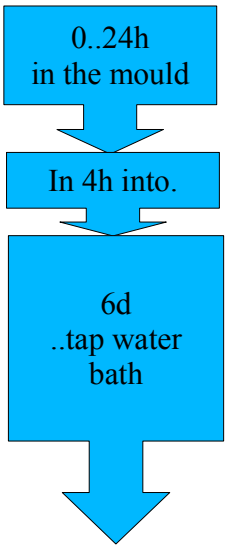
The test requires five specimens. The test surface of each specimen is approx. 140 mm x 150 mm.

The PTFE plate is centred in the mould in order to divide the mould into halves. The vertical PTFE plate serves as a mould surface. The centred plate can be fixed by two other plates which are placed vertically. The concrete surface at the PTFE plate is the test surface. The PTFE plate is not treated with any demoulding agent

IIt is permissible to insert two PTFE plates at two opposed vertical sides. In this case, the specimens are cut through the centre between the two test surfaces after storage under water. For larger aggregate size the PTFE plate can be placed only at one side of the mould.



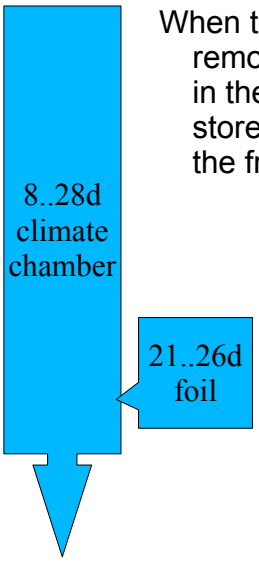
Specimen Preparing [1..7[d



During the first day after casting the cubes are stored in the moulds and protected against drying by use of a polyethylene sheet. The air temperature is (20 ± 2) °C.

After (24 ± 2) h, the cubes are removed from the moulds and placed for 6 days in a bath with tap water having a temperature of (20 ± 2) °C.

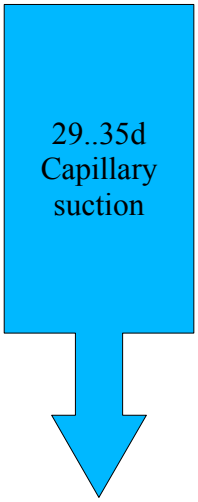
Specimen Preparing [8..28[d



When the cubes are 7 days old they are removed from the water bath and placed in the climate chamber where they are stored for surface drying for 21 days until the freeze-thaw testing starts.

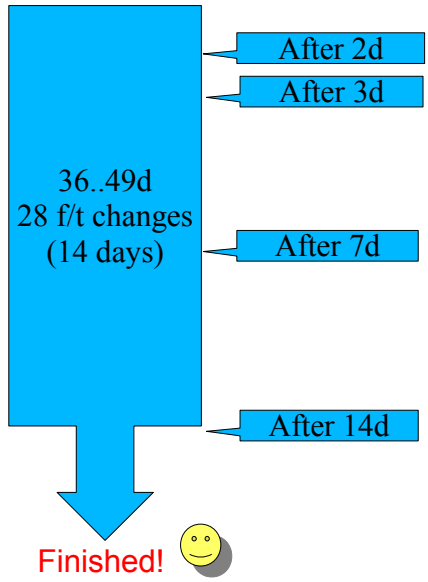
Between 21st and 26th day after casting the specimens the lateral surfaces are either covered with aluminium foil glued with butyl rubber or sealed with a solvent-free epoxy resin. Immediately after this treatment the specimens are returned to the climate chamber.

Capillary Suction [29..35[d



The freeze-thaw test starts after 28 days with the resaturation of the specimens. Following dry storage, the specimens are placed in the test containers on the (5 ± 0,1) mm high spacers with the test surface downwards. Subsequently, the freezing medium is poured into the container to a height of (10 ± 1) mm without wetting the specimen's top.
During the capillary suction the test container is closed. The capillary suction period is seven days at a temperature of (20 ± 2) °C. Check and adjust the liquid level above at regular intervals, depending on the suction capacity of the material during capillary suction. The weight gain of the specimens is measured.

CDF Freeze-Thaw Test [36..49[d

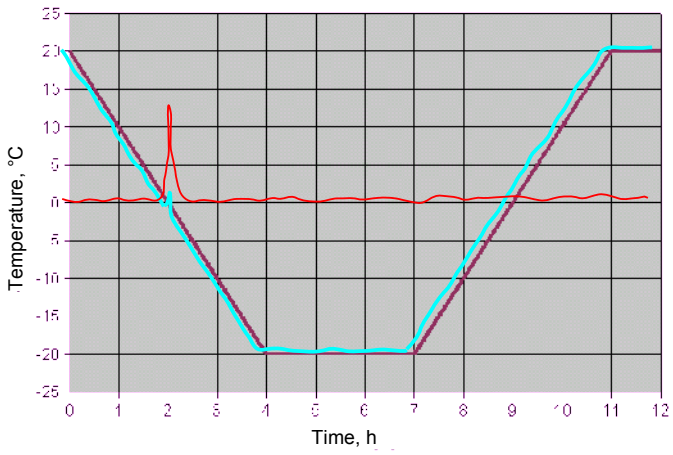


Before starting the freeze-thaw cycles, remove loosely adhering particles and dirt from the test surfaces of the specimens by treatment in the ultrasonic bath.The material removed is discarded.

Test procedure after 4±1, 6±1, 14±1and 28 freeze thaw cycles

carry out the following procedure for each specimen while the temperature is above 15 °C.

Temperature Program



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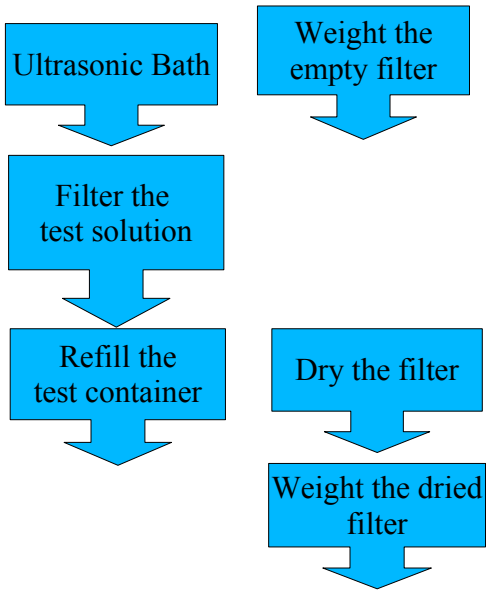
The Test Procedure



To remove loosely adhering scaled material from the test surface, the test container is dipped into the contact liquid of an ultrasonic bath and subjected to ultrasonic cleaning for three minutes.

The solution comprising the scaled material is filtered. The suitable paper filter is subsequently dried at (110 ± 10) °C for 24 hours and cooled for (60 ± 5) min at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 5) %. The mass of the filter containing the dried scaled material ms+f is weighed to 0,1 g. The mass of the empty filter mf is determined before with the same accuracy.

Result

The cumulative mass of the dried scaled material ms, n is determined by:

$m_{s,n} = m_{s,before} + (m_{s+f} - m_f)$ [g]

For each measurement and each specimen calculate Sn, the cumulative amount of scaled material per unit area after n cycles, in kilograms per square metre:

$S_n = (m_{s,n}[g] / A[mm^2]) * 1000$ $[kg/m^2]$

S_n is the mass of scaled material related to the test surface after the n-th cycle in kg/m^2,
$m_{s,n}$ is the cumulative mass of dried scaled material after n freeze-thaw cycle, A is the test surface in mm^2, calculated on the basis of the linear dimensions as the average of at least two measurements determined to the nearest 0,5 mm.

Test Report

- Reference to this Technical Specification;
- origin, size and marking of the specimens;
- concrete identification;
- the composition of the freezing medium;
- amount of cumulative scaled material for each specimen as well as the mean value and the standard deviation in kilograms per square metre rounded to the nearest 0,001 kg/m²,
after (4 ± 1), (6 ± 1), (14 ± 1) and 28 cycles;
- visual assessment (cracks, scaling from aggregate particles) before the start and after (4 ± 1), (6 ± 1), (14 ± 1) and 28 cycles
- any deviations from this alternative test procedure;
- *optional*: Mass of solution sucked up during the capillary suction period for each specimen as well as the mean value and the standard deviation;
- *optional*: The composition of the concrete.

CF Test

- The CF test is the CDF test without De-icing agent so:
- The freezing medium is de-ionised water only
- The number of frost cycles is 56 = 28 days
- The test procedure is done after : (14 ± 1), (28 ± 1), (42 ± 1) and 56 freeze thaw cycles

CIF Test

Capillary Suction, **I***nternal damage* and **F**reeze-thaw Test

It's an extension of the CDF test

Additional equippment:

- Test container for ultrasonic transit time measurement
- Calibration test specimen is used for calibration of the ultrasonic transit time measurement. Dimensions 150 x 110 x 70 mm
- Specimen carrier as particle collector

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Other differnces to the CDF test

- Height of he specimen 70mm±2mm
- After storage under water the specimen are cut on the rough top side to 110 mm, if 2 PTFE plates are used the specimen are vertically divided.
- The mass of the specimen during drying has to be monitored
- Test at 0, and every 4^{th} or 6^{th} cycle

The additional test procedures

1. Surface scaling (as CDF)

2. Moisture uptake

Set the specimen with he test surface on a towel
Dry all other surface
Place the specimen carrier on the a balance
Place the specimen on the specimen carrier

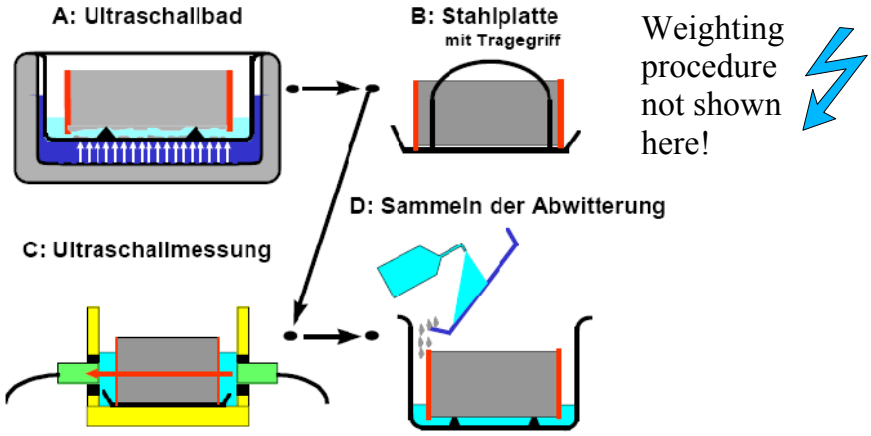
3. Internal damage

Fill the test container 10mm over transducers withh test liquid
Measure the transit time w/o specimen and with
the specimen in both directions.

CIF Test of Scaling and Inner Damage

A: Ultrasonic Scaling

B: Specimen Handling



C: Ultrasonic Transition Time loss for inner Damage

D: Collecting the Scaled Material

CIF Damage Criterion

The specimen is damaged when the quadrat of the change of transit time during the test is less 80%

$Ru,n = (t\_0 / t\_n)^2$

t_0 = transit time in the specimen at the beginning
t_n = transit time in the specimen after n cycles

Before the test the interested parties must agree how many cycles the specimen should withstand the damge criterion.

So the number of ycles s not fixed!

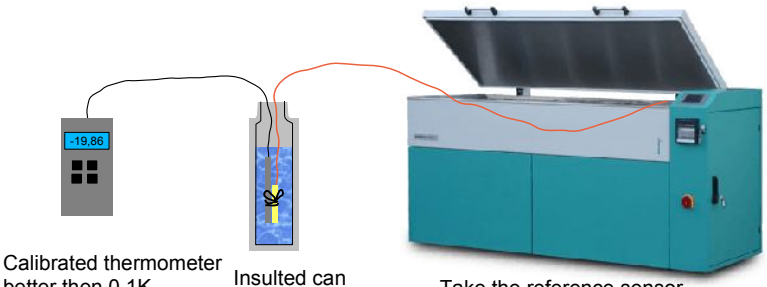
How to run failure-free

- Check the freeze protection all two month
- Check the cooling water in summer or open the window
- Check the liquid level of the coolant
- Record the temperatures
- Don´t use wipes of paper
- Make a test run after a long stop

Finally...

- More information at
  www.schleibinger.com

Temperature Calibration



Calibrated thermometer better then 0.1K

Insulted can with fluid

Take the reference sensor out of he bath

Please check the temperature deviation

The temperature accuracy is the sum of the measurement accuracy abd the accuracy of the controler.
Please always record the system temperature during the test

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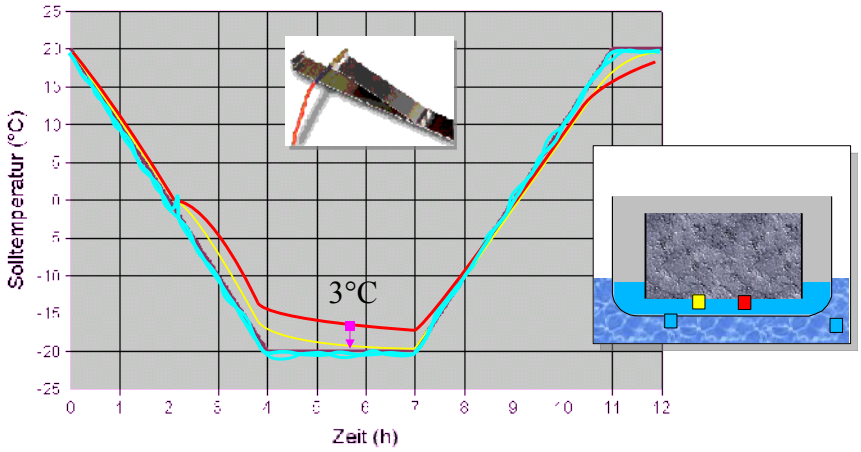
Sensor Not in the Right Position?



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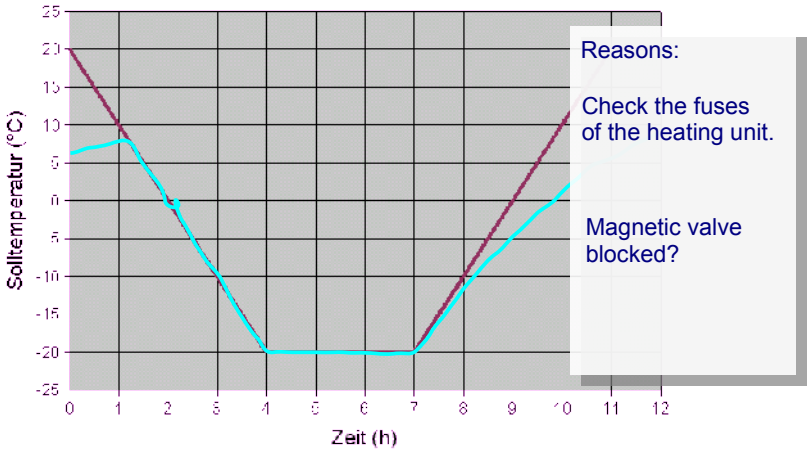
Less heating power?

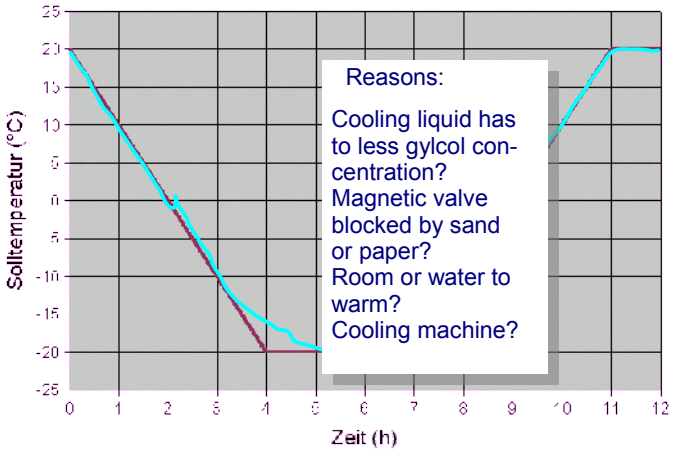


Reasons:

Check the fuses of the heating unit.

Magnetic valve blocked?

Not enough cooling power?



Cause of failure

- Less freeze protection of the coolant
- Too warm, no cooling water
- Paper fibres in the coolant
- Blocked Condenser
- Too much/less coolant

Freeze Protection

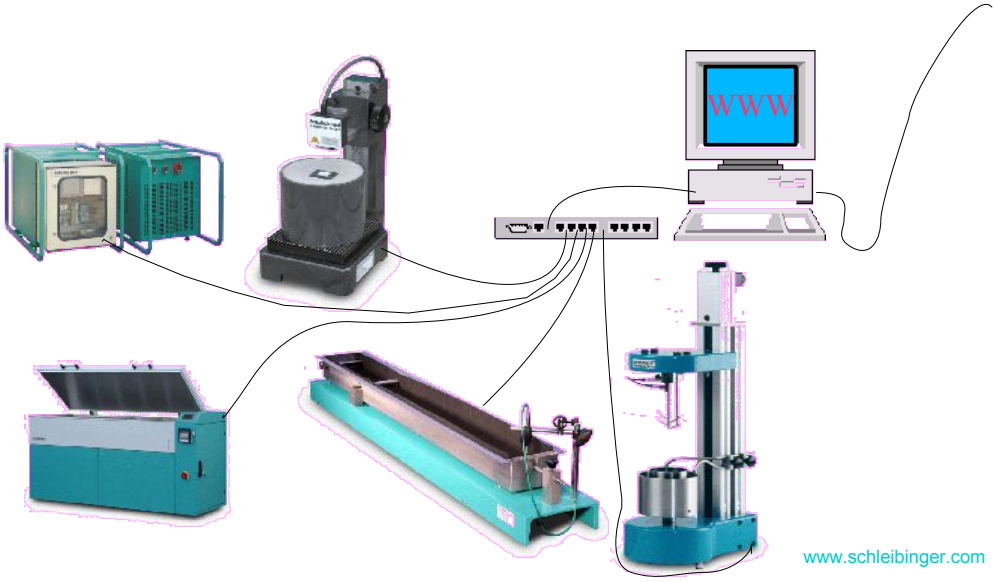
Minimum -45°C oder density 1,078 g/cm³.

Frostschutz Freeze Protection	Dichte Density	Zu ersetzende Menge Coolant to be replaced
-35 °C	1,070	7 Ltr.
-30 °C	1,065	12 Ltr.
-28 °C	1,060	20 Ltr.
-20 °C	1,050	30 Ltr.

Electronic/Software

Check the calibration data after RAM RESET
or after installing a new software.

All schleibinger equipment comes with Web interface



Finally...

- More information at
  www.schleibinger.com

Schleibinger Wordwide

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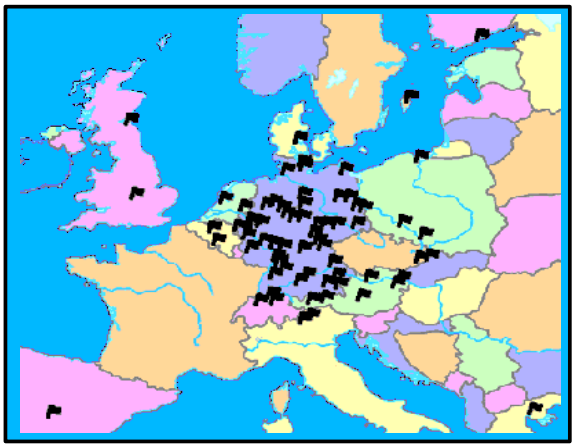
Installations Europe



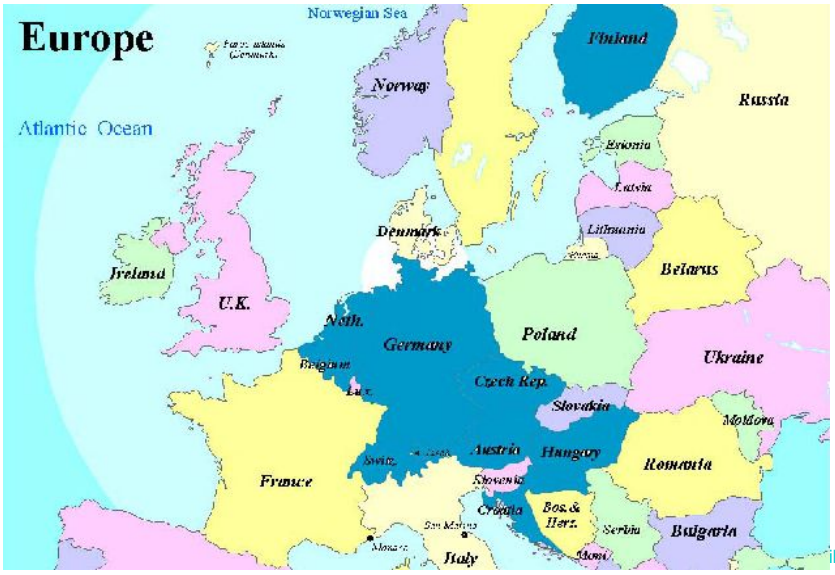
Controller und Programming

- Schleibinger controller and software is fully developed for CDF equipment
- Operating of the equipment by a colour touch screen
- Additional profiles can be programmed by the user
- Data can be uploaded by a optional WEB interface

Schleibinger Geräte

- Formation 1990
- New Building and Company Structure 1995
- Two Owners: Greim and Teubert
- 6 Employees
- Annual Sales 750.000 EUR

CDF Customers, Countries



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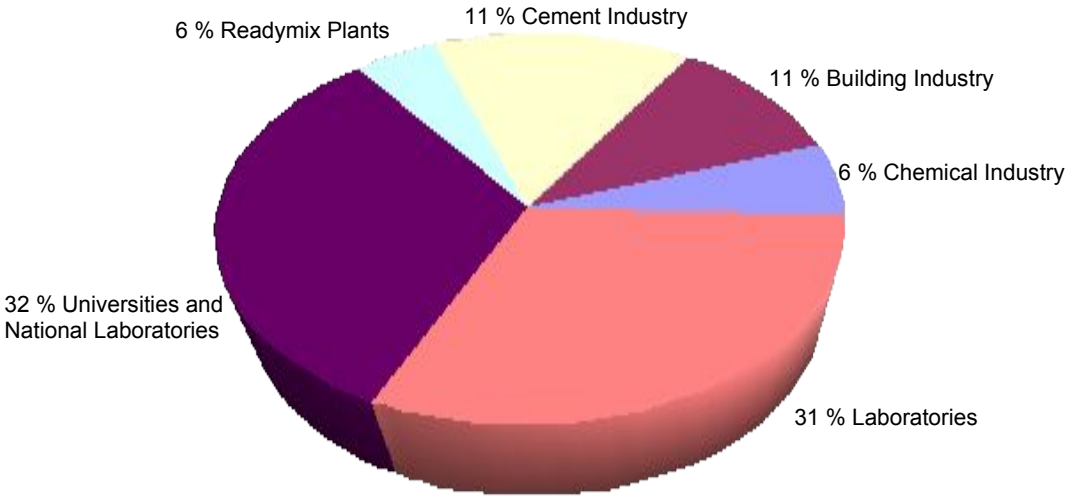
CDF Customers



Decision Support

- Slabtester for casually capacity (low capital cost)
- Cube Test is less expensive, but inprecise
- CDF-Test is quick and accurate

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Please notice, that I am not a expert for building materials, but a specialist for mechanical engeneering. You will get prefessional Informations ....

But let me say my opinion from my point of view.

If you leave aside expert knowledge, local recomendations and the customer requirement .....

Required Cooling Power

- Max. power is required at the freezing point of the test liquid

- Released energy from 8 kg test liquid is: Q = 2 700 kJ = 45 kWmin = 0,75 kWh
- 1,2 kg water must be evaporated to compensate this effect
- or 6 kg refrigerant