# Different approaches to humidity generators, using concepts with carriergas-free evaporators cold trap and mixing design

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## Content:

- introduction company
- humidity generation with carriergas-free evaporators, examples
- humidity generation with cold trap, example
- humidity generation with gas mixing design, example

# aDROP GmbH:

- start in 1997 as spin-off from the Department of Fluid Mechanics Erlangen (Prof. Durst).
- change of the legal form 1998 into ‚aDROP Feuchtemeßtechnik GmbH‘.
- key activities:
  - direct evaporators without carrier-gas and low dead volume [0,1 g/h …10 kg/h]
  - humidity generators (mainly custom design)
  - custom assemblies for research and production
  - contract research
- CAD 3D design and in-house manufacture, mostly in stainless steel
- microcontroller and electronic development (AVR 8bit, ARM 32bit)
- staff 8 coworkers + freelancers (CNC, LabView,..)

# A: humidity generator with carriergas-free evaporator

**direct evaporator:**

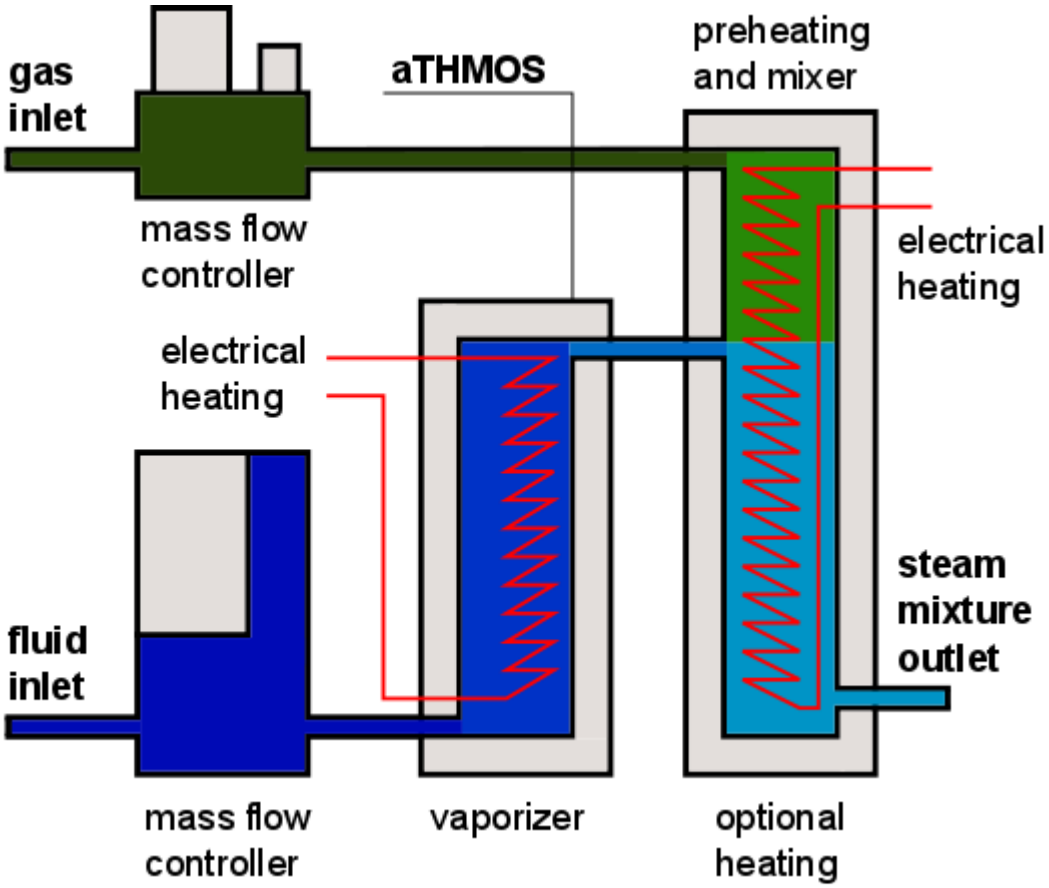
- The fluid is dosed into the evaporator, which converts it into pure gas (overheated steam), without any additional (carrier-) gas.

- evaporation takes place within a porous stainless steel matrix. A temperature control supplies the necessary enthalpy. The interaction of pressure drop, temperature control and heatexchange provides a wide operational range, going up to 1:50 from min to max flow.

- high accuracy dosing in the liquid phase (eg. Coriolis massflow- controller) is much easier than accurate dosing in the gas phase.

- a stand-alone direct evaporator allows a modular rig design: Unlike spray gas evaporation, gas flow, steam flow, pressure and temperature can be adjusted individually.

# A: humidity generator with carriergas-free evaporator

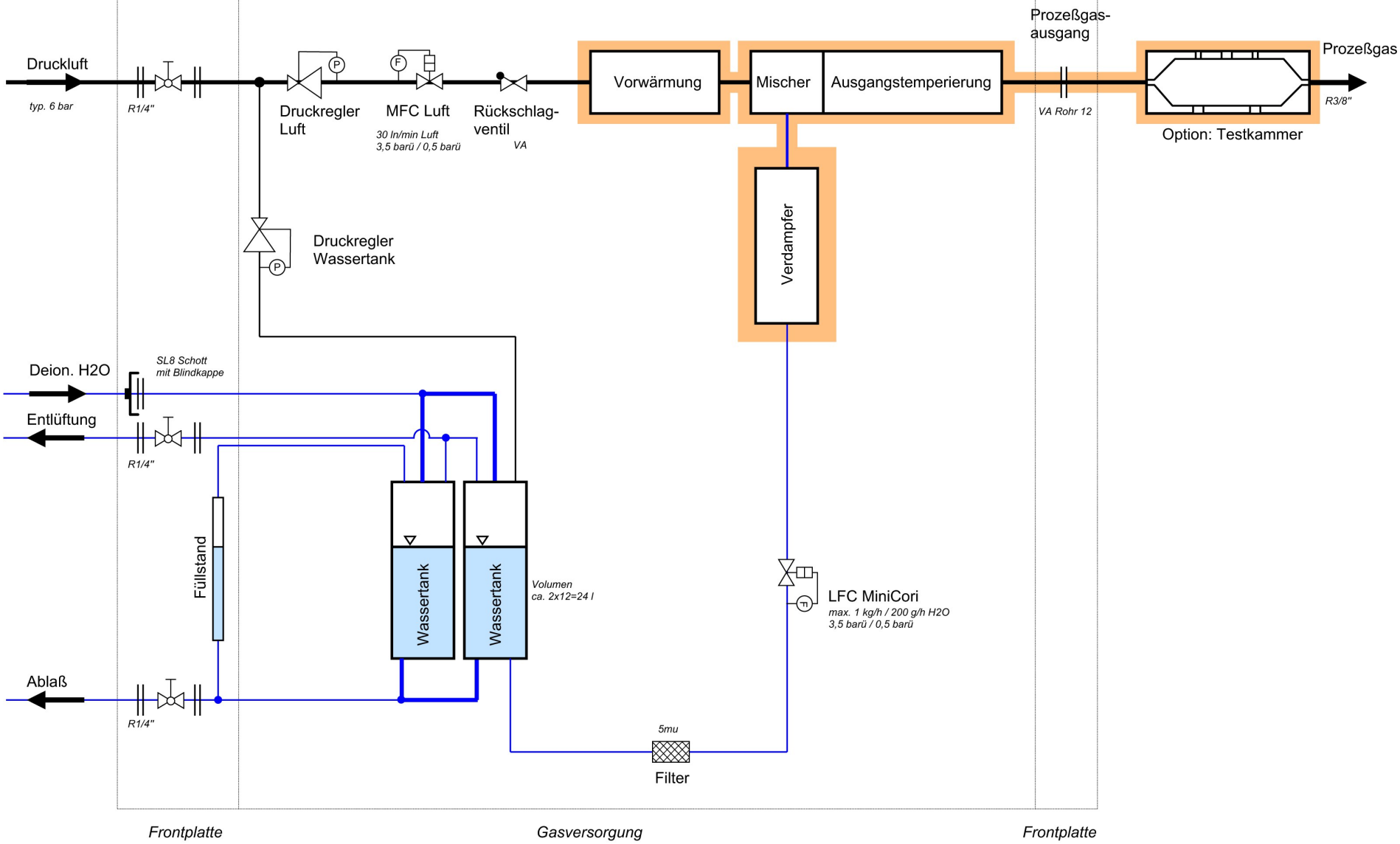


# A: humidity generator with carriergas-free evaporator

- evaporation of fuel, up to 480°C evaporation temperatur, additional gas on demand
- bench design with external mass flow controllers

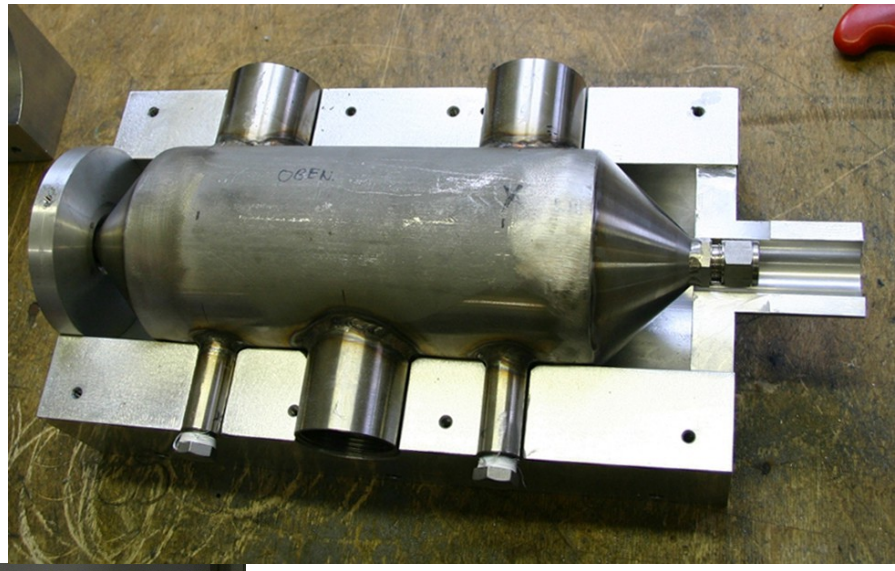
# A: humidity generator with carriergas-free evaporator

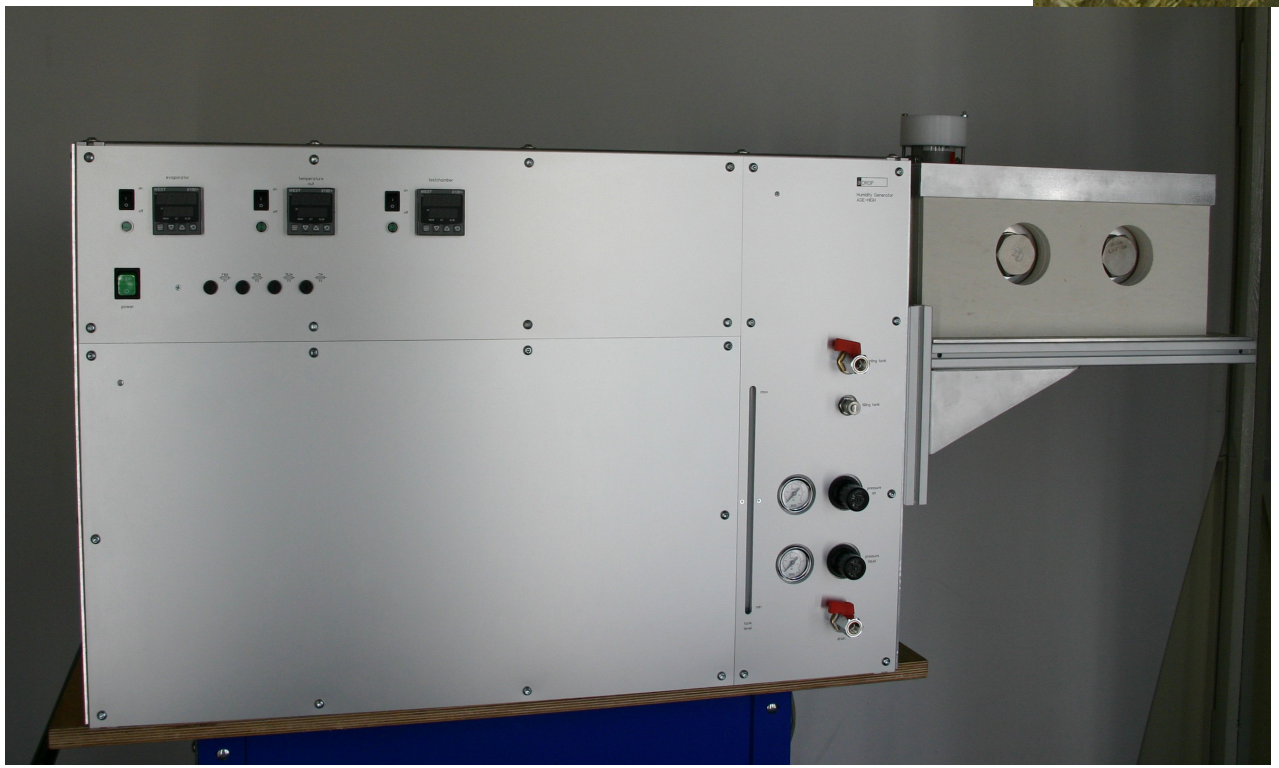
- calibration set-up for industrial high-temperature psychrometers,
- with test chamber up to 350°C



# •A: humidity generator with carriergas-free evaporator

test chamber

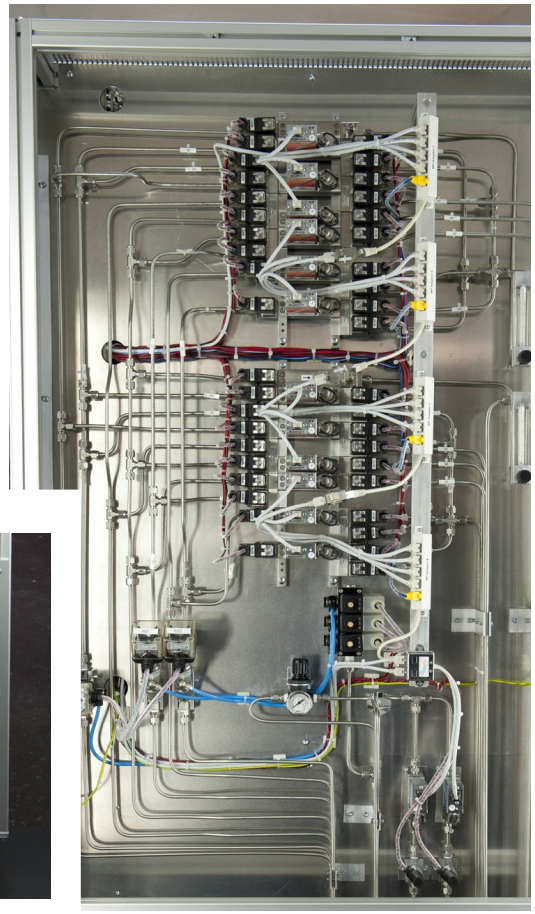




generator with test chamber

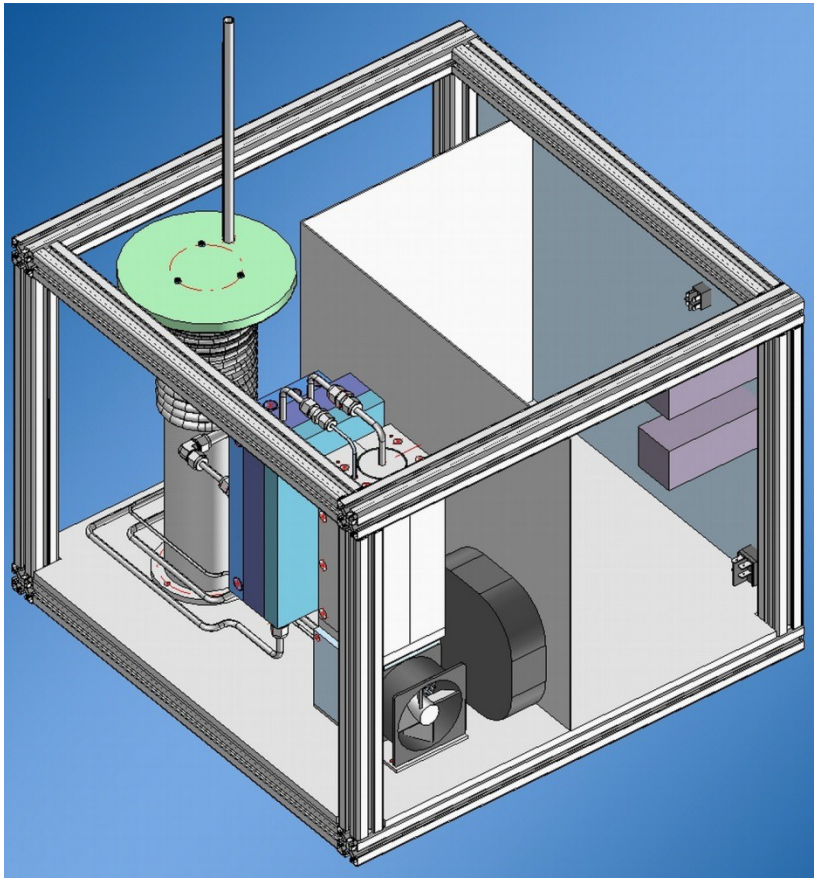
# •A: humidity generator with carriergas-free evaporator

- twin test rig for fuel cell testing
- 2x DV2-evaporator with dosing
- sequential control and DAQ with LabView
- including the safety provisions for H2 and CO



# A: humidity generator with carriergas-free evaporator

- two parallel evaporators, with a steam flow range of 1:1000 (2,5 g/h … 2.500 g/h $H_2O$)
- $T_{out}$ bis 600°C



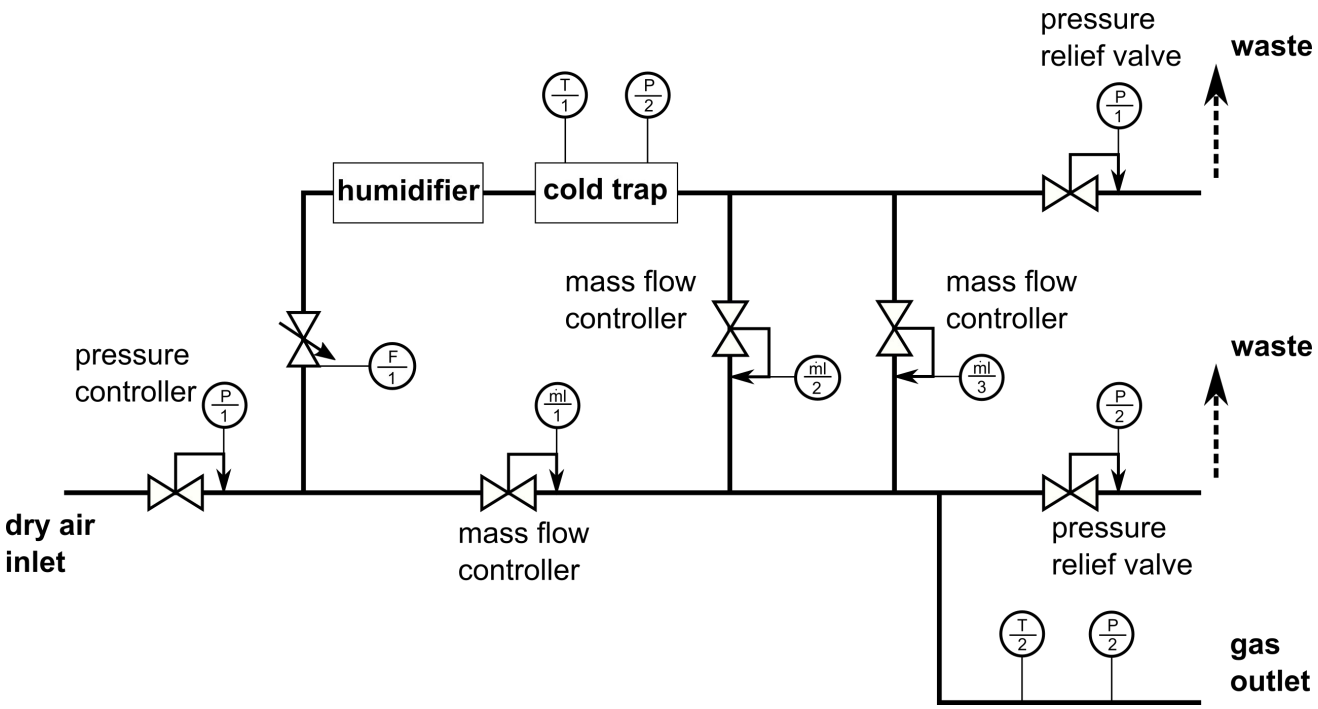
# working ranges of direct evaporator (referring to $H_2O$)

| | Dynamik | Bereich Min. | Bereich Max. | Druck stand. | Druck Max. | Temp. Stand. | Temp. Max. |
|---|---|---|---|---|---|---|---|
| **Direkt-Verdampfer** | | | | | | | |
| µSTEAM | 1:20 (50) | 0,1…2 g/h | 0,5…10 g/h | 6 barg | 100+ barg | 200°C | |
| DV2 | 1:40 (50) | 1…50 g/h | 2,5…100 g/h | 6 barg | 100+ barg | 200°C | 400°C |
| DV4 | 1:40 (50) | 10…500 g/h | 50…2.500 g/h | 6 barg | 100+ barg | 200°C | 450°C |
| DV1C | 1:40 (50) | | 100...4.000 g/h | 6 barg | 50 barg | 300°C | 450°C |
| DV3 | 1:40 (50) | 100…6.000 g/h | 200…10.000 g/h | 6 barg | 30 barg | 300°C | 400°C |
| **Direkt-Verdampfer** | | | | | | | |
| aTHMOS | 1:10 | 100…1.000 g/h | 200….2.000 g/h | 6 barg | | 200°C | |
| aTHMOS-RS | 1:10 | 500…5.000 g/h | 600…6.000 g/h | 6 barg | | 200°C | |
| **Spray-Verdampfer (zB. $SiCl_{4)}$** | | | | | | | |
| SGV1 | 1:50+ | 10…500 g/h | 50…2.500 g/h | 6 barg | | 250°C | 450°C |

# B: humidity generator using a cold trap

**cold trap**:

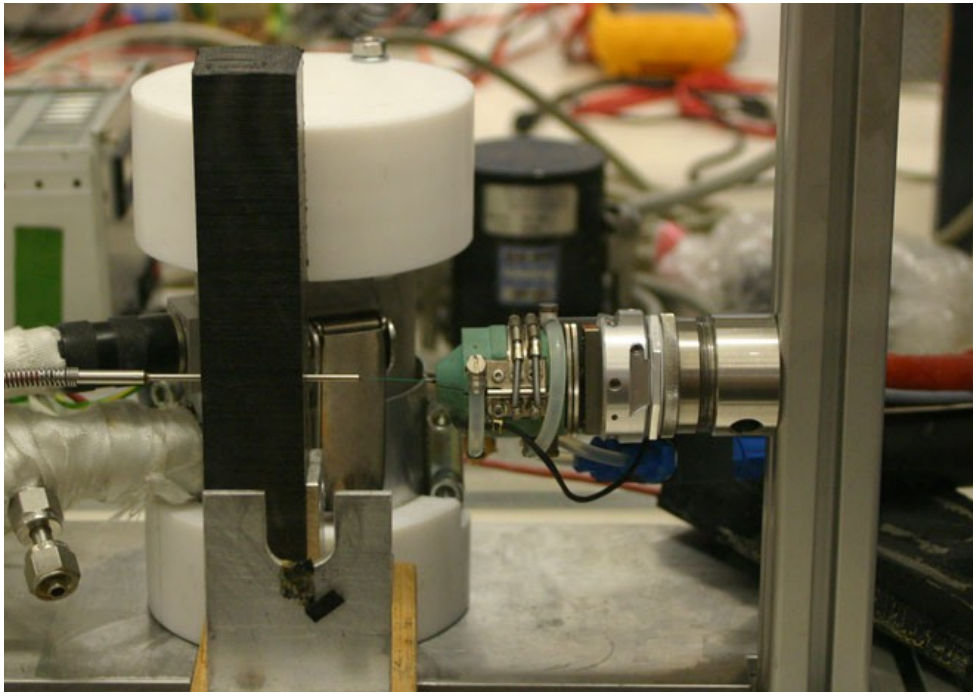
- a humidified gas is cooled down below dewpoint, condensating the surplus water vapour
- peltier-operated cooling and precise temperature/pressure measurement can lead to high accuacy dewpoints.
- dewpoint range can be expanded by dilution provisions



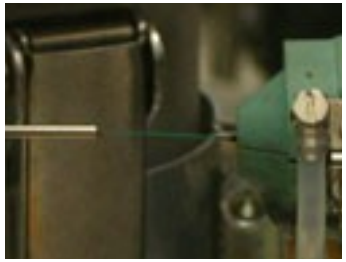
# B: humidity generator using a cold trap

- provides a stable rh- and temp.-environment for proteine cristalls while x-ray diffraction meas.
- Tdp and t stable within 0,03°C, range 3...40°C Tdp without pressure of dilution measures

aCCU-Feuchtegenerator
Oben: Gasversorgung
Unten: Steuer- und Leistungselektronik

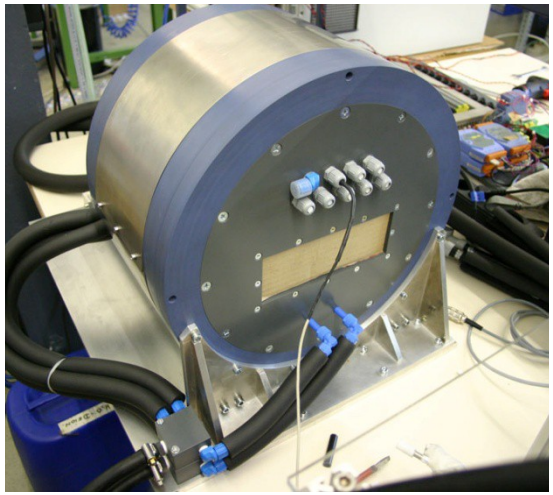


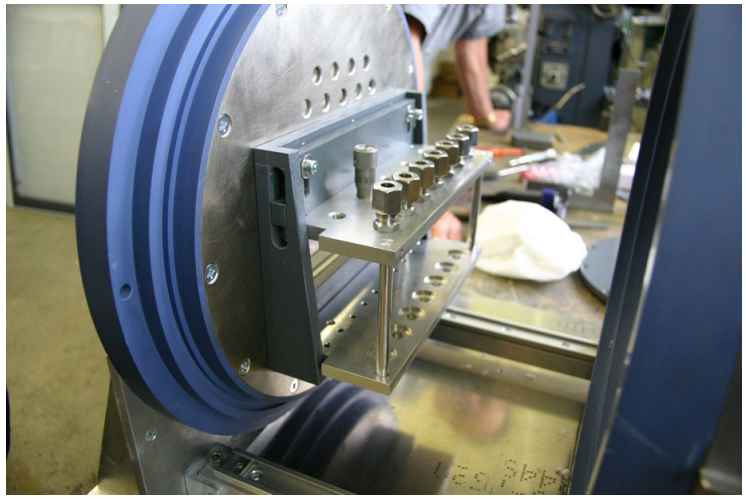
Meßkopf / Wärmetauscher mit Goniometeraufnahme für Proteinmontage in der Röntgenkristallographieanlage



# B: humidity generator using a cold trap

- temperature controlled test chamber for the humidity generator
- used for testing of concrete elongation while ageing etc.





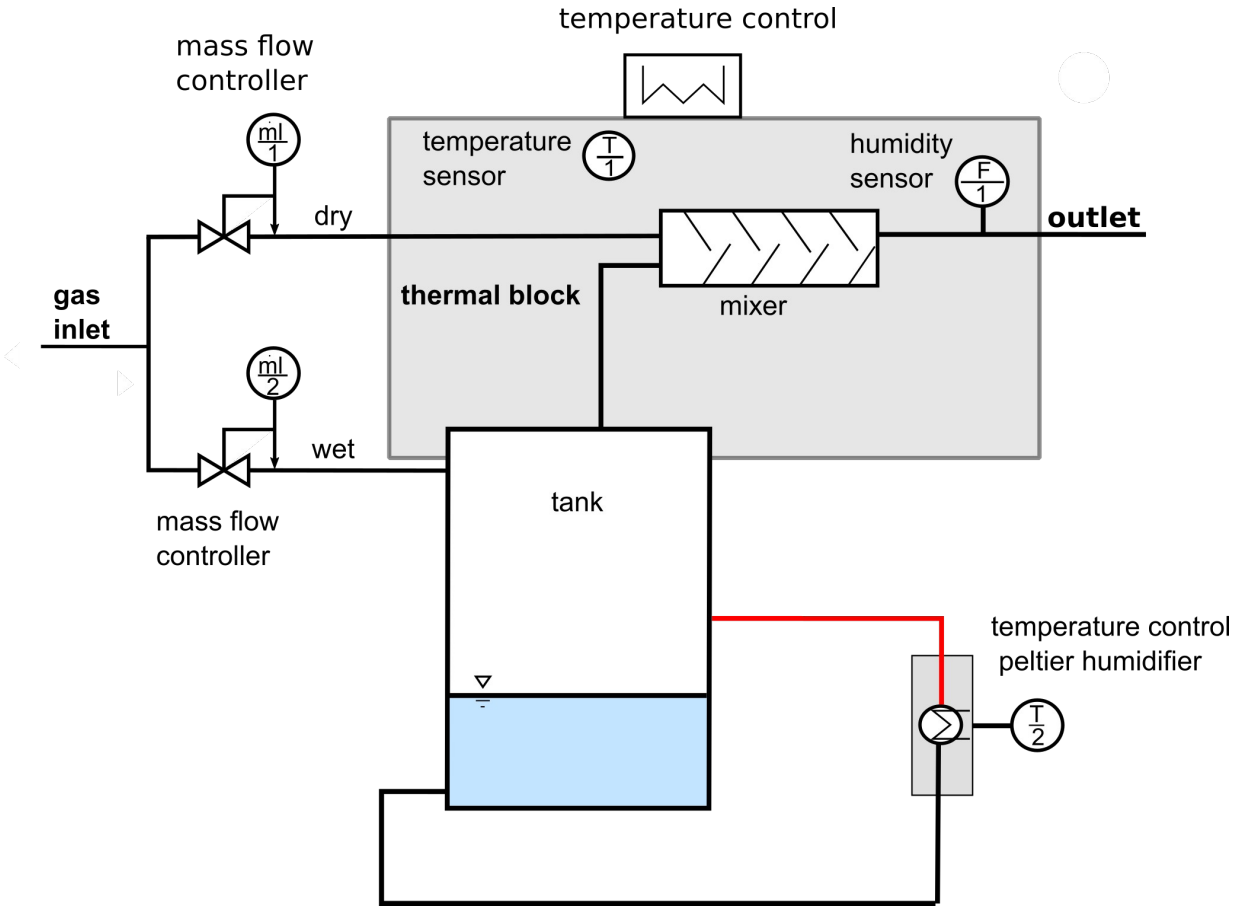
Kammerdeckel geschlossen, mit Sensordurchführungen und Temperierungs-leitungen

Kammerdeckel aufgeschoben mit innenliegender Probenhalterung

Kammer mit außenliegenden Temperiungsrohren und Isolation

# C: humidity generator using a mixing design

- humidity generation using a reference sensor
- less severe demands regarding the humidity generation due to the presence of a control sensor
- high accuracy requires high precision control sensors



# C: humidity generator using a mixing design

- aGEPRO with rated flow 0,2 … 1,5 ln/min
- T [ 5 … 70°C], rh [5 … 95%rF], accuracy control sensor ca. 1% rh, 0,2°C
- control mode: set T+rh or Tdp (dewpoint)

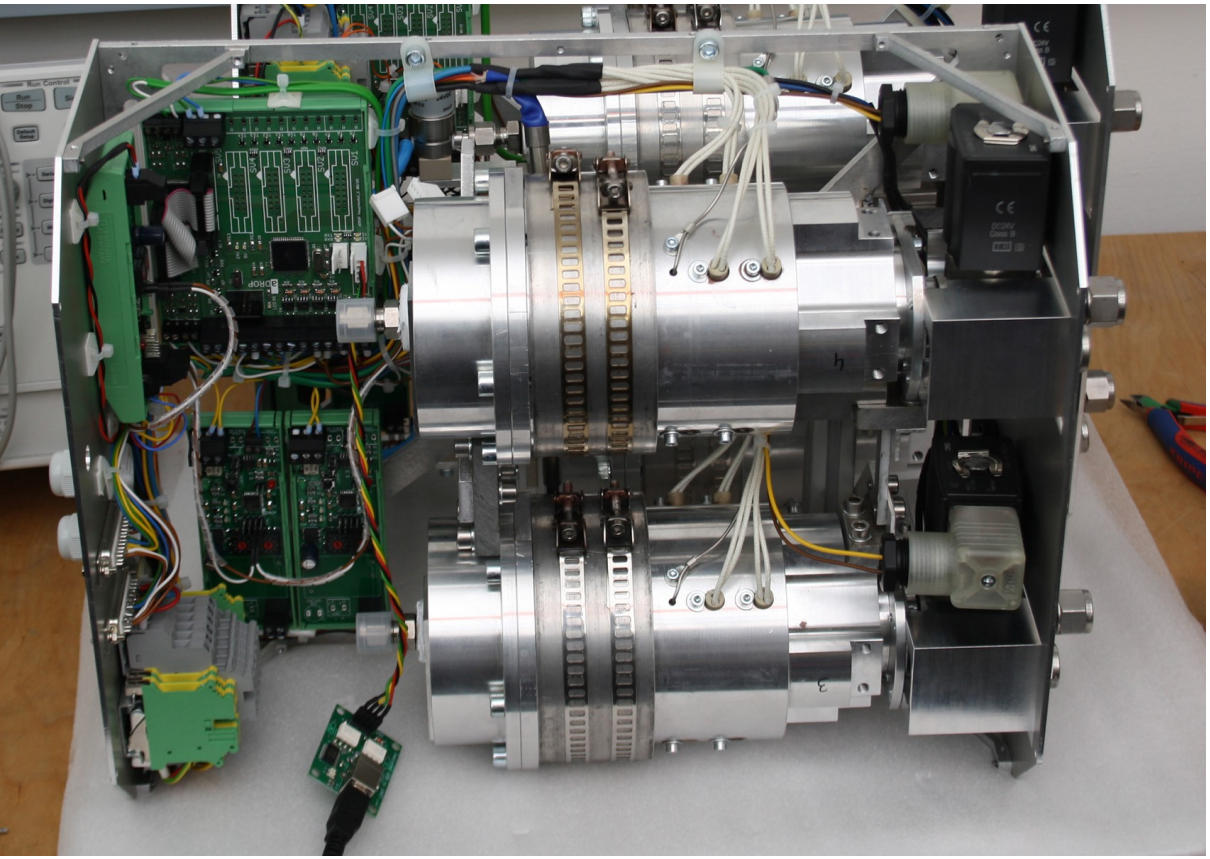
# C: humidity generator using a mixing design

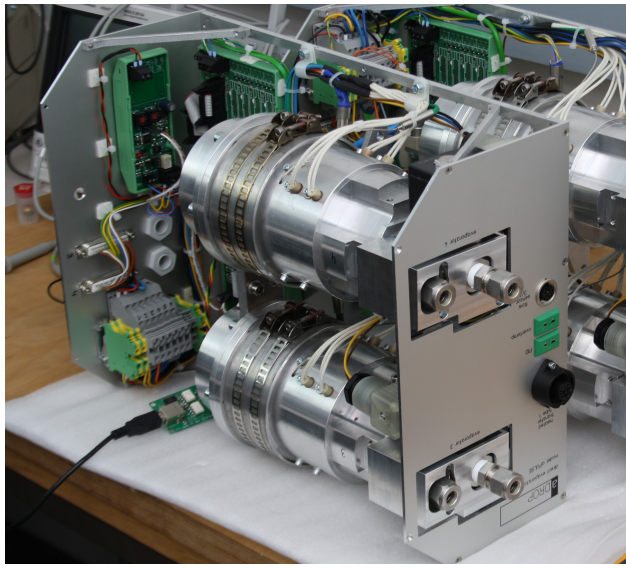
- aGEPRO with dewpoint mirror control for production
- small amounts of gases like $NO_2$ can be introduced to check cross sensitivity

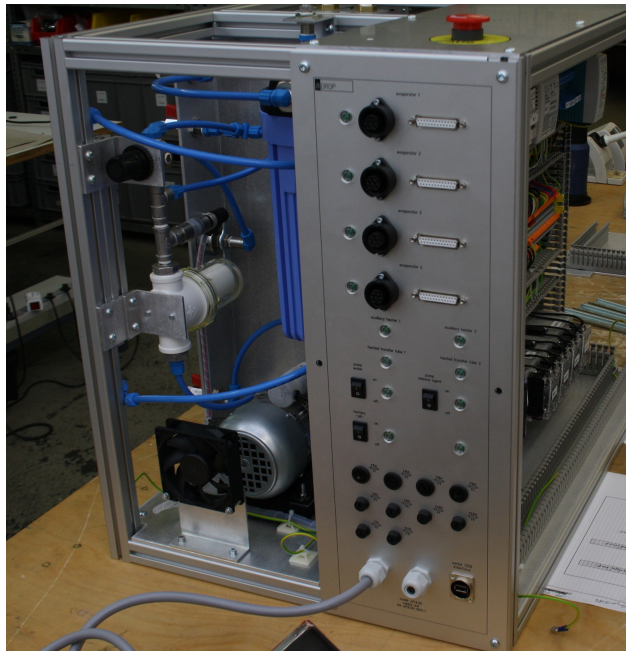
- **C: humidity generator using a mixing design**

# something different...

- generation of steam pulses with valve and nozzle
- using a high speed valve $f_{rep}$ ca. 25 Hz
- using PWM modulation
- defined pulses below 1 sec
- continous ca. 1,5 kg/h
- short time up to 5 kg/h







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