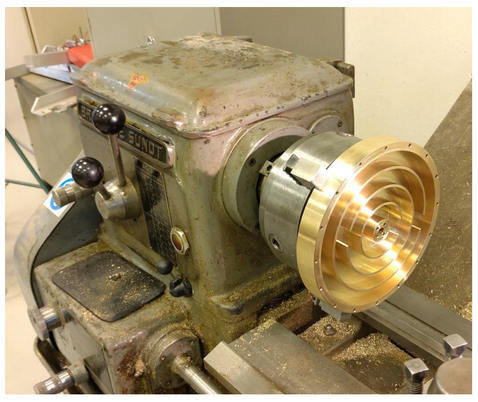


CONSTRUCTION OF A PRIMARY DEWPOINT GENERATOR

P. Rothmund, R. A. Bergerud, Å. A. F. Olsen
Justervesenet, Kjeller, Norway
E-mail (corresponding author): pro@justervesenet.no

Justervesenet

INTRODUCTION

At JV we recently upgraded the dewpoint setup, in the operating range from -80 °C frostpoint to +80 °C dewpoint, with a custom design fabricated inhouse. We chose a well proven principle known as “one temperature, single pressure and single flow” [1] [2].
We developed the generator in several stages, first a prototype to run studies and characterize parameters. Based on our findings, we produced a second version with an additional pre-saturator, and finally the third version with improved finish, like gold plated saturator.

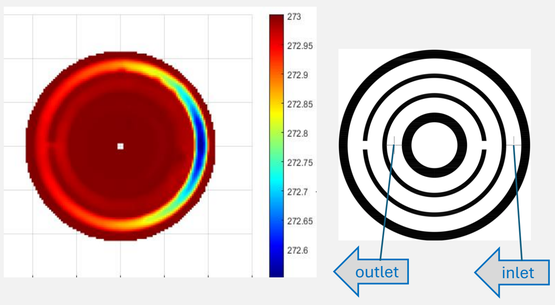
The main element of this Dewpoint Generator is a saturator, made by a labyrinth disc half filled with water. When a low stream of air is spreading above the water/ice surface, it saturates slowly on its path. The temperature of this fully saturated airstream is the dew/frost-point temperature.

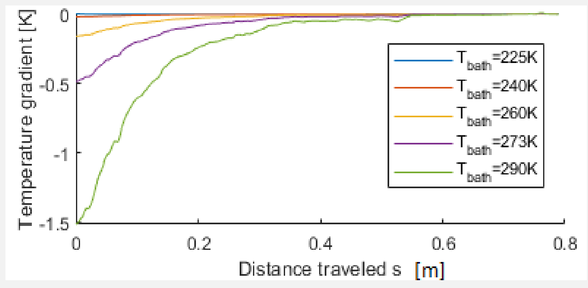
Abbreviations:
Saturator (SAT), Presatorator (PreSAT), Dewpoint Generator (DPG), Dewpoint Mirror (DPM),
Standard Platinum Resistance Thermometer (SPRT), Platinum Resistance Thermometer 100 Ohm (Pt100),
National Metrology Institute (NMI)

STUDIES ON A PROTOTYPE

Simulations of temperature gradients along the saturation path

Simulated temperatures on water/ice surface and brass body, data shown with a dry airflow of 3 l/min, at a bath temperature of 273 K (left graph) and a variation of 5 temperatures (right graph).

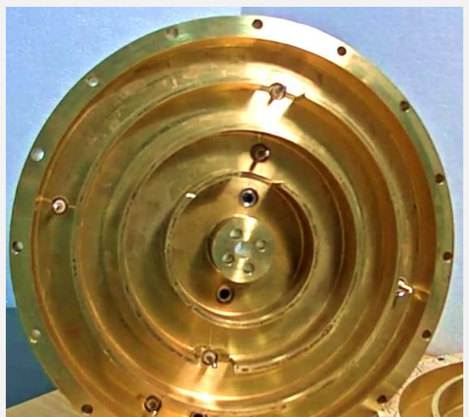




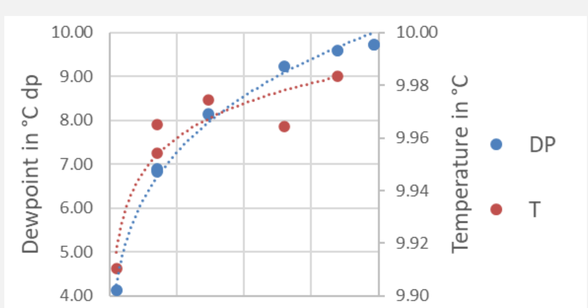
➔ Temperature decreases significantly at the inlet
➔ Less temperature impact in the brass body

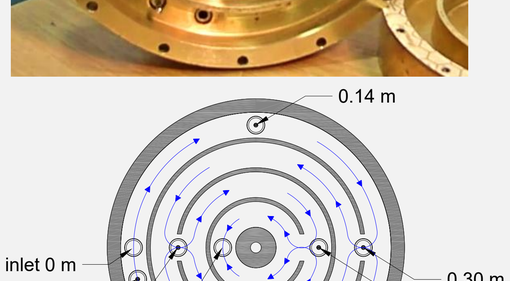
➔ Gradient increases with bath temperature

Measurements along the saturation path



Pt100 are fixed in fittings, thermally isolated from the brass body, measuring temperature in the airstream.
In the second measurement setup, this fittings are used to collect air samples for dewpoint measurements.
Data shown at bath temperature of 10 °C and dry air flow of 1.5 l/min.

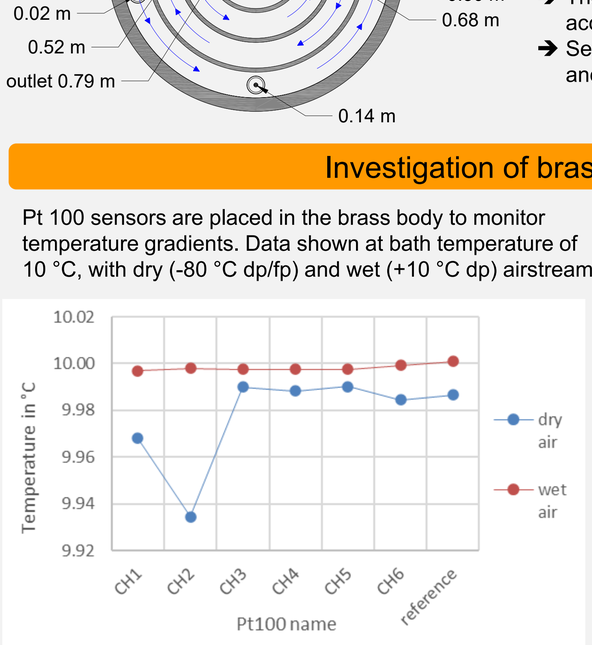


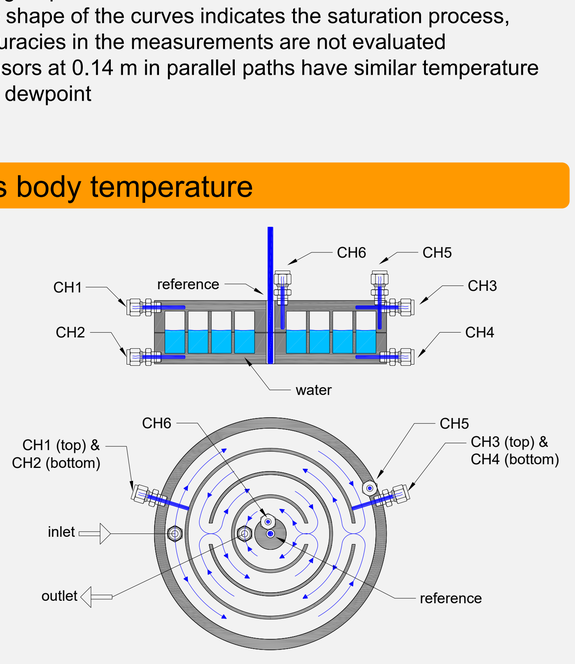


➔ Red dots indicate temperature, starting with high deviation to bath temperature due to evaporation
➔ Blue dots indicate dewpoint, airstream is slowly saturated along its path
➔ The shape of the curves indicates the saturation process, accuracies in the measurements are not evaluated
➔ Sensors at 0.14 m in parallel paths have similar temperature and dewpoint

Investigation of brass body temperature

Pt 100 sensors are placed in the brass body to monitor temperature gradients. Data shown at bath temperature of 10 °C, with dry (-80 °C dp/fp) and wet (+10 °C dp) airstream.

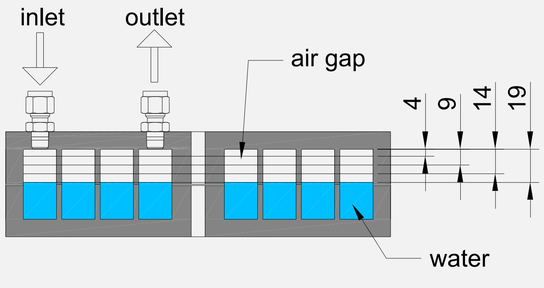


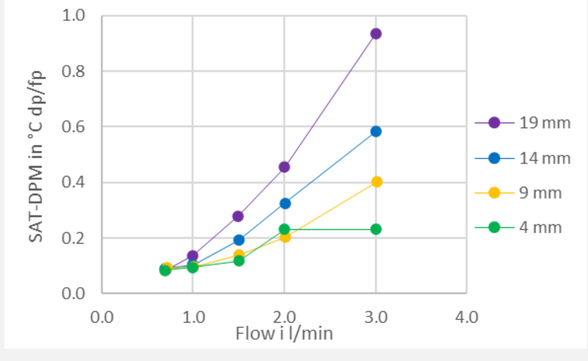


➔ Water evaporates from the surface and cools down the whole device, strongest close to the inlet at CH2 and CH1.
➔ The temperature of other Pt100, placed further away from the inlet, have similar temperatures, including the reference sensor in the center.
➔ When wet air is supplied, all sensors measure temperatures close to bath temperature.

Influence of air gap above the water surface

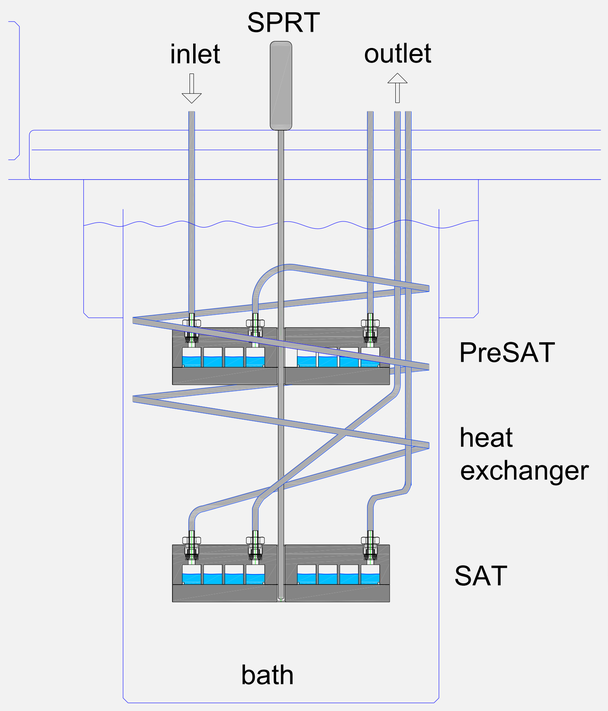
Temperature deviation between SAT & DPM. Data shown at a bath temperature of 10 °C, with various flow and air gap heights.

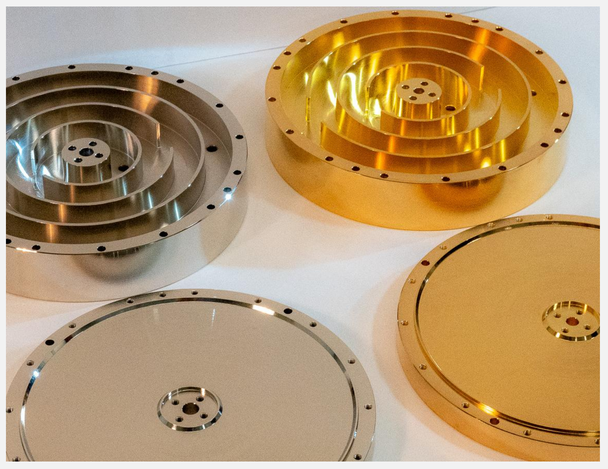




➔ Best saturation with little airgap

PRIMARY GENERATOR

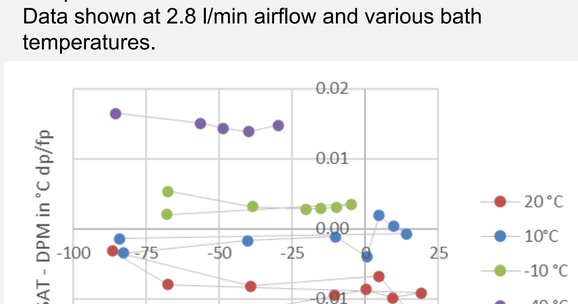




DPG features
- Traceably calibrated SPRT
- SAT & PreSAT
- Heat exchanger
- Gold plated SAT
- Nickel plated PreSat
- High quality fittings
- Electropolished pipes
- Membrane valves
- Flow controller
- Indium gasket
- Pressure monitoring
- Stable calibration bath
- Heated pipes
- PrePreSAT at high dewpoints

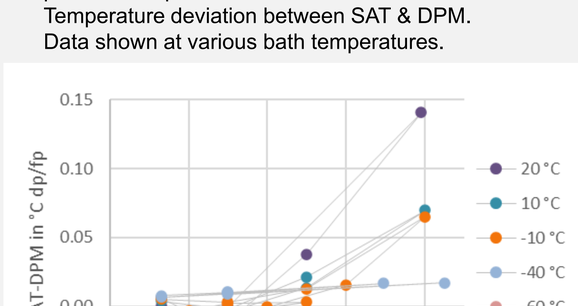
Degree of saturation

Variation in dewpoint of supplied air.
Temperature deviation between SAT & DPM.
Data shown at 2.8 l/min airflow and various bath temperatures.



➔ Similar for dry or humid air, god saturation
➔ Variation due to measurement uncertainty

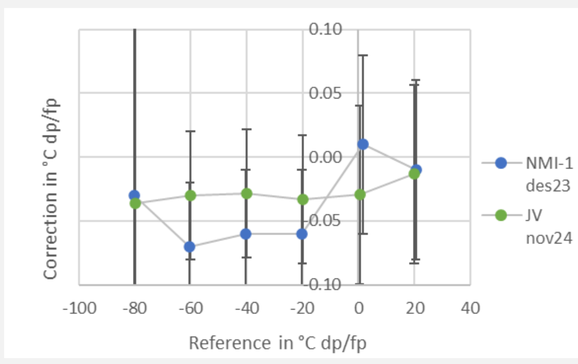
Variation in flow of supplied dry air, corrected for pressure drop.
Temperature deviation between SAT & DPM.
Data shown at various bath temperatures.



➔ Sufficient saturation up to 3 l/min airflow
➔ High bath temperature is most challenging

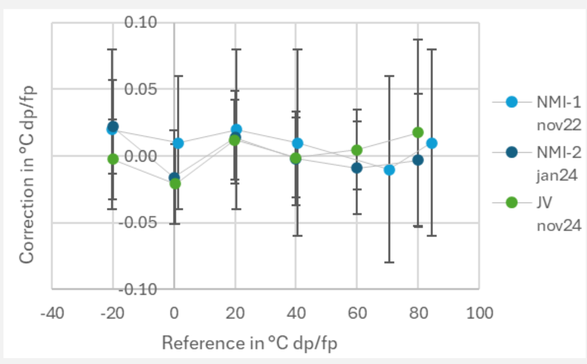
Validation against dewpoint mirrors with calibration from other NMIs

Low dewpoints with DPM MBW373LX.



➔ Equivalence of correction values

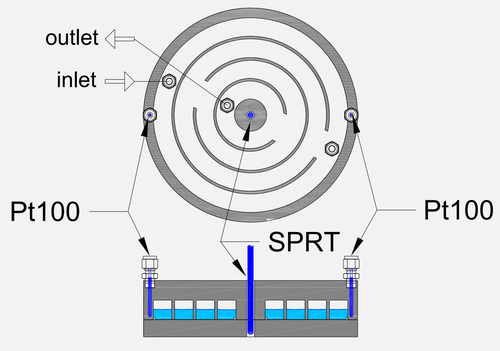
High dewpoints with DPM MBW373HX.



➔ Equivalence of correction values

CHOICES FOR DESIGN AND OPERATION

- Strategically placed Pt100 to monitor temperature gradients in the brass body, which are used in the uncertainty budget. These gradients also change significantly if all water evaporates.
- Most of the saturation is in the PreSAT and only the final touch is in the SAT.
- Same design of SAT and PreSAT.
- Always flow of 3 l/min to assure same conditions.
- Pipe outlet is always heated to decrease adsorption and avoid condensation.
- Monitoring with a calibrated DPM to check performance.



REFERENCE

[1] D Hudoklin et al.: The new LMK primary standard for dew-point sensor calibration: evaluation of the high-range saturator efficiency. 2008 Int J Thermophys 29, 1652–1659
[2] C FitzGerald et al.: Development of a new primary humidity measurement standard. 2020 Meas. Sci. Technol. 31 024007