Retrofitting Timber Frame Walls with Vacuum Insulation Panels

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Invited lecture based on the following article:

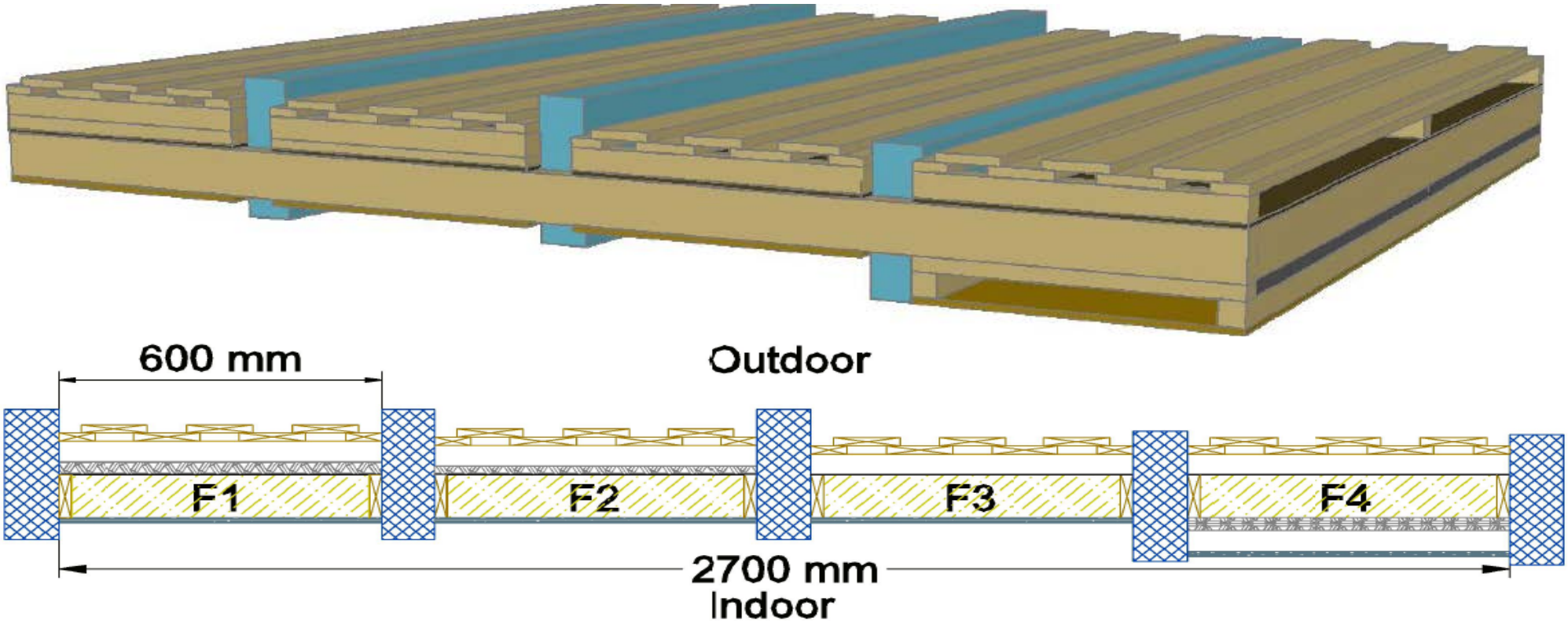
E. Sveipe, B. P. Jelle, E. Wegger, S. Uvsløkk, S. Grynning, J. V. Thue, B. Time and A. Gustavsen, "Improving Thermal Insulation of Timber Frame Walls by Retrofitting with Vacuum Insulation Panels – Experimental and Theoretical Investigations", *Journal of Building Physics*, 35, 168-188, 2011.

Building Enclosure Science & Technology (BEST 3 - 2012), Atlanta, Georgia, U.S.A., 2-4 April, 2012.

Introduction

- Many timber frame buildings from the 1970s in Norway.
  - Many ready to be retrofitted.
- Vacuum insulation panels (VIPs) as a high performance thermal insulation solution.
  - Allows for retrofitting with a minimal additional thickness to the existing wall.
- Improving thermal performance is often recommended done by exterior retrofitting.
  - This can not uncritically be performed with vapour tight VIPs.

Wall Module Build-Up



- Field 1 and 2: VIPs on exterior side
- Field 3: Reference field
- Field 4: VIPs on interior side

Note that the vapour barrier was omitted

Procedure

Outdoor temperature -18 °C, and RH ~60 %.

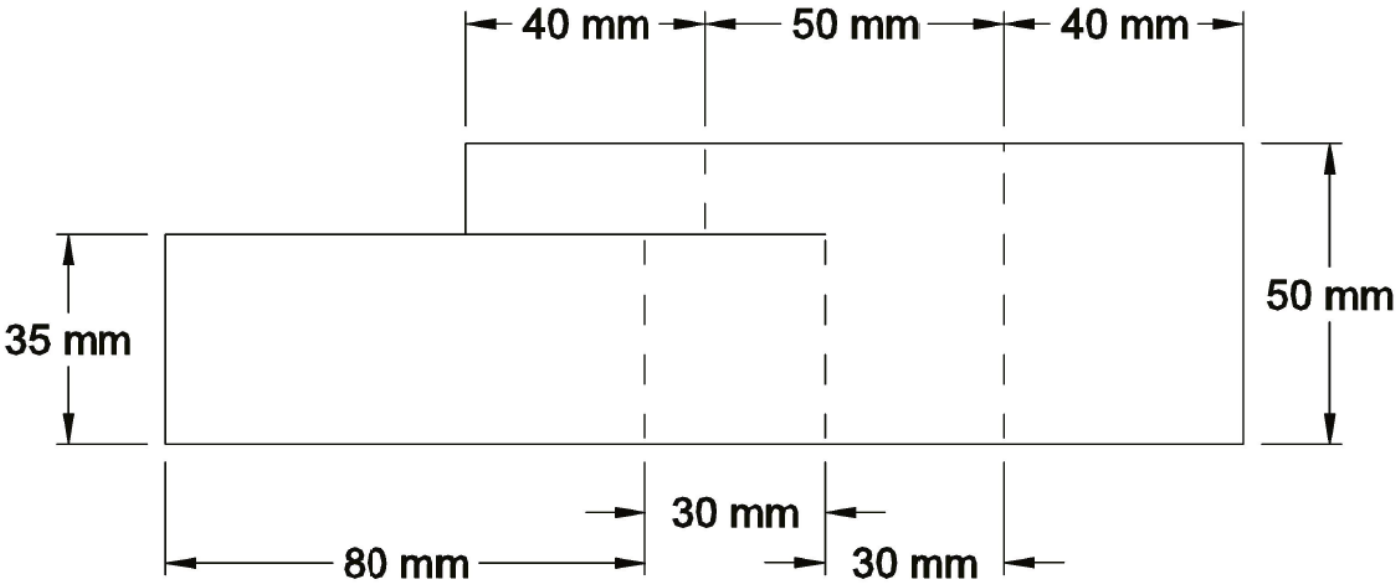
Indoor temperature 20 °C.

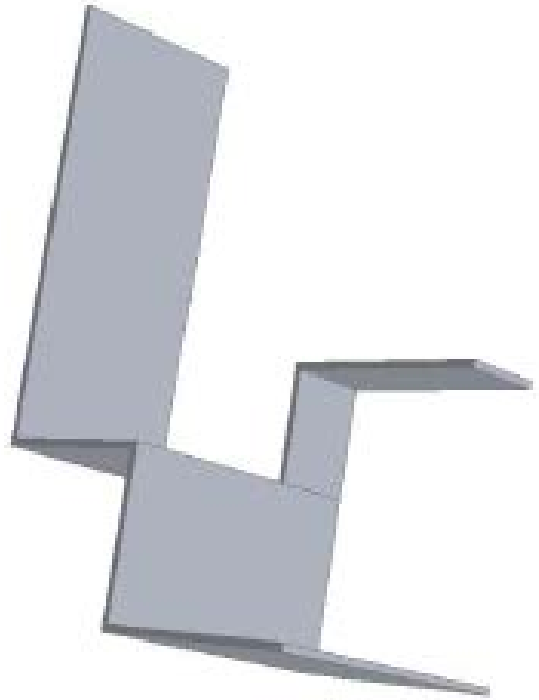
Four climate steps on interior side:

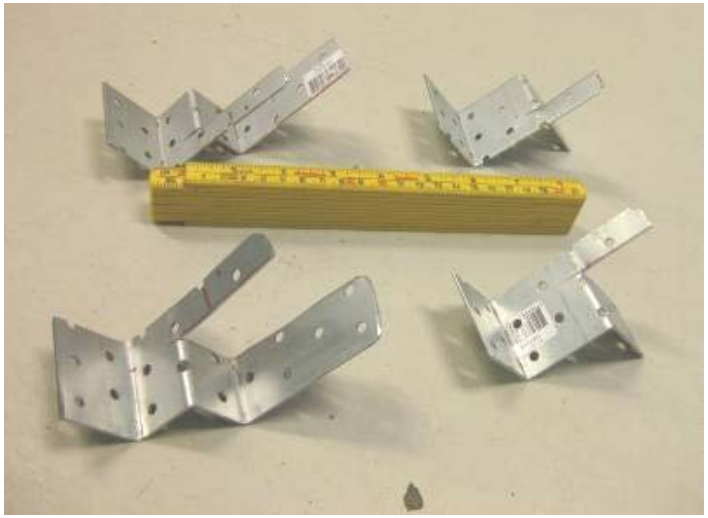
1. RH 30 % (~ 4 g/m^3) [1]
2. RH 40 % (~ 6 g/m^3) [1]
3. RH 50 % (~ 8 g/m^3) [1]
4. RH 60 % (~ 10 g/m^3) [1]

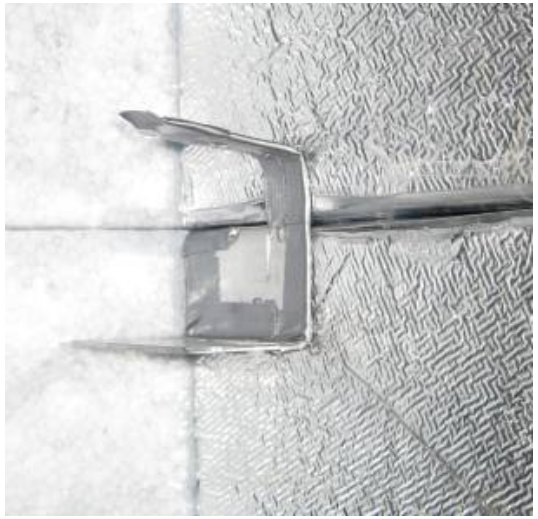
[1] approximately the internal moisture excess that equals the given indoor RH for an indoor temperature of 20 °C, an outdoor RH of 60 %, and an outdoor temperature of −18 °C.

VIP Fastening Bracket



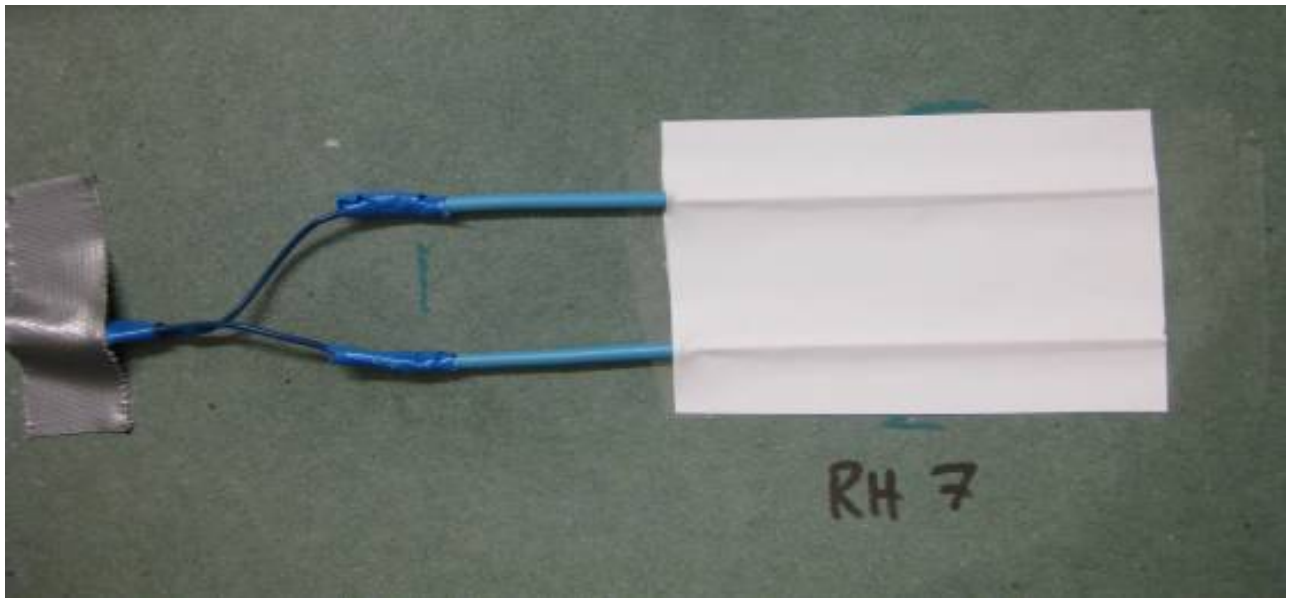






Wetness Sensor

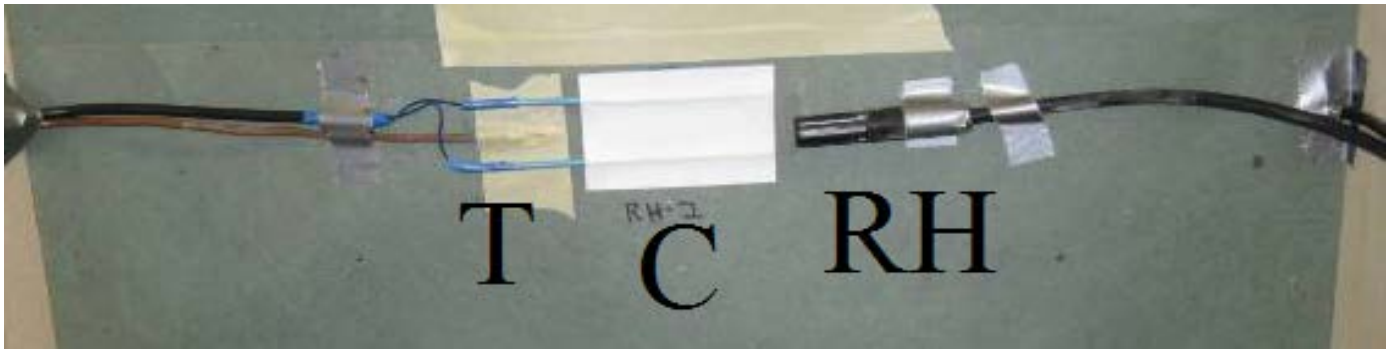
- An alternative moisture sensor called the wetness sensor.



- The intention is to measure condensation on the surface of a material layer better than a normal air RH sensor.

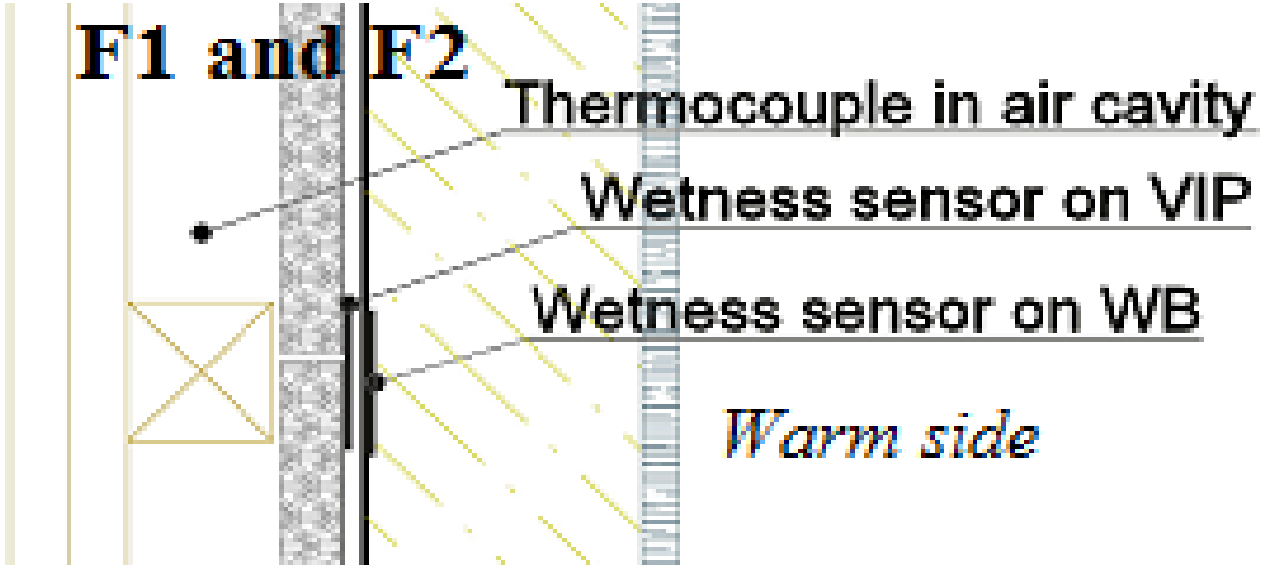
Sensors

- In total: 36 sensors in the four fields in the test module.

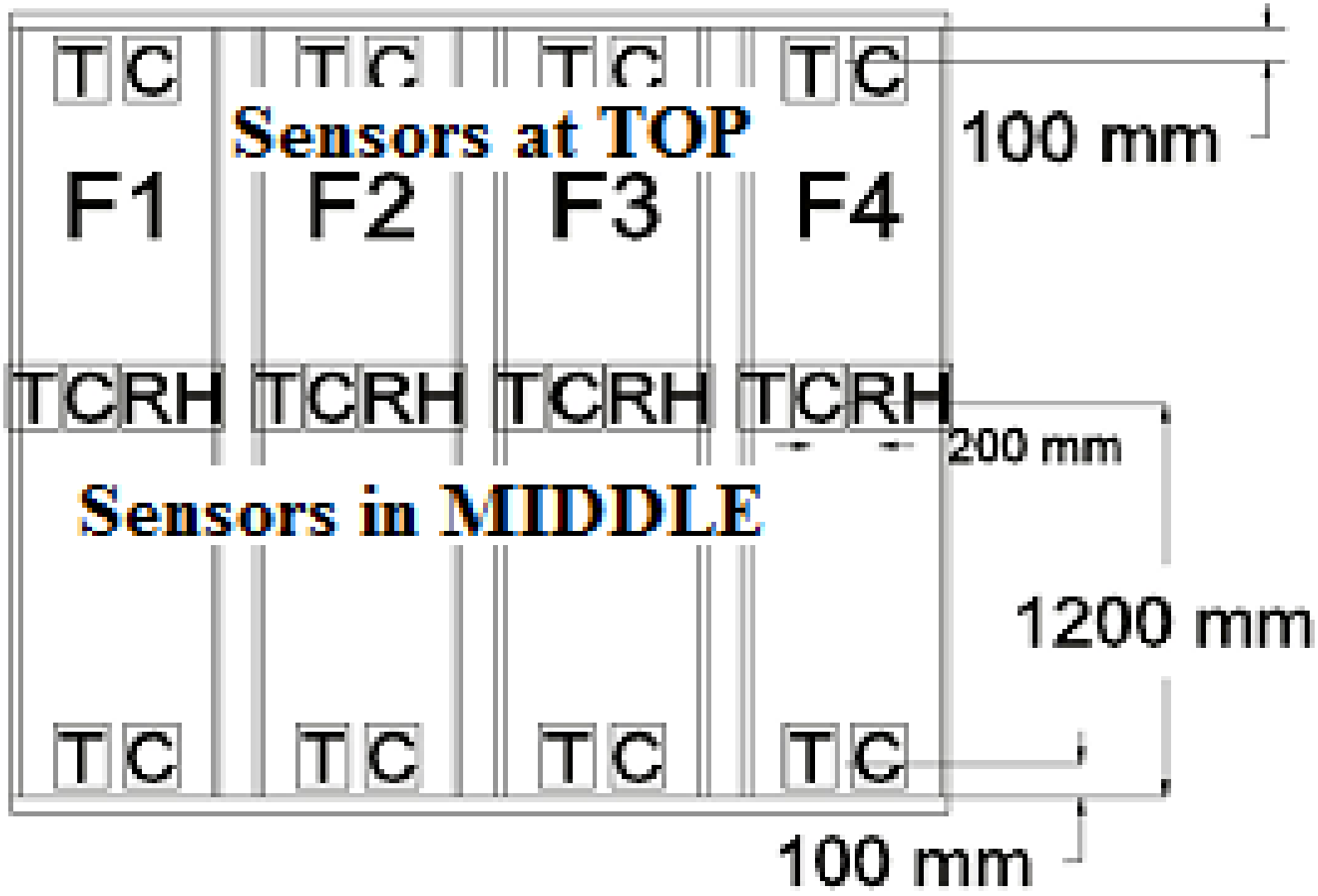


- Thermocouple (T), wetness sensor (C) RH air sensor (RH).

- Placing of sensors in cross-section.



Sensor Locations

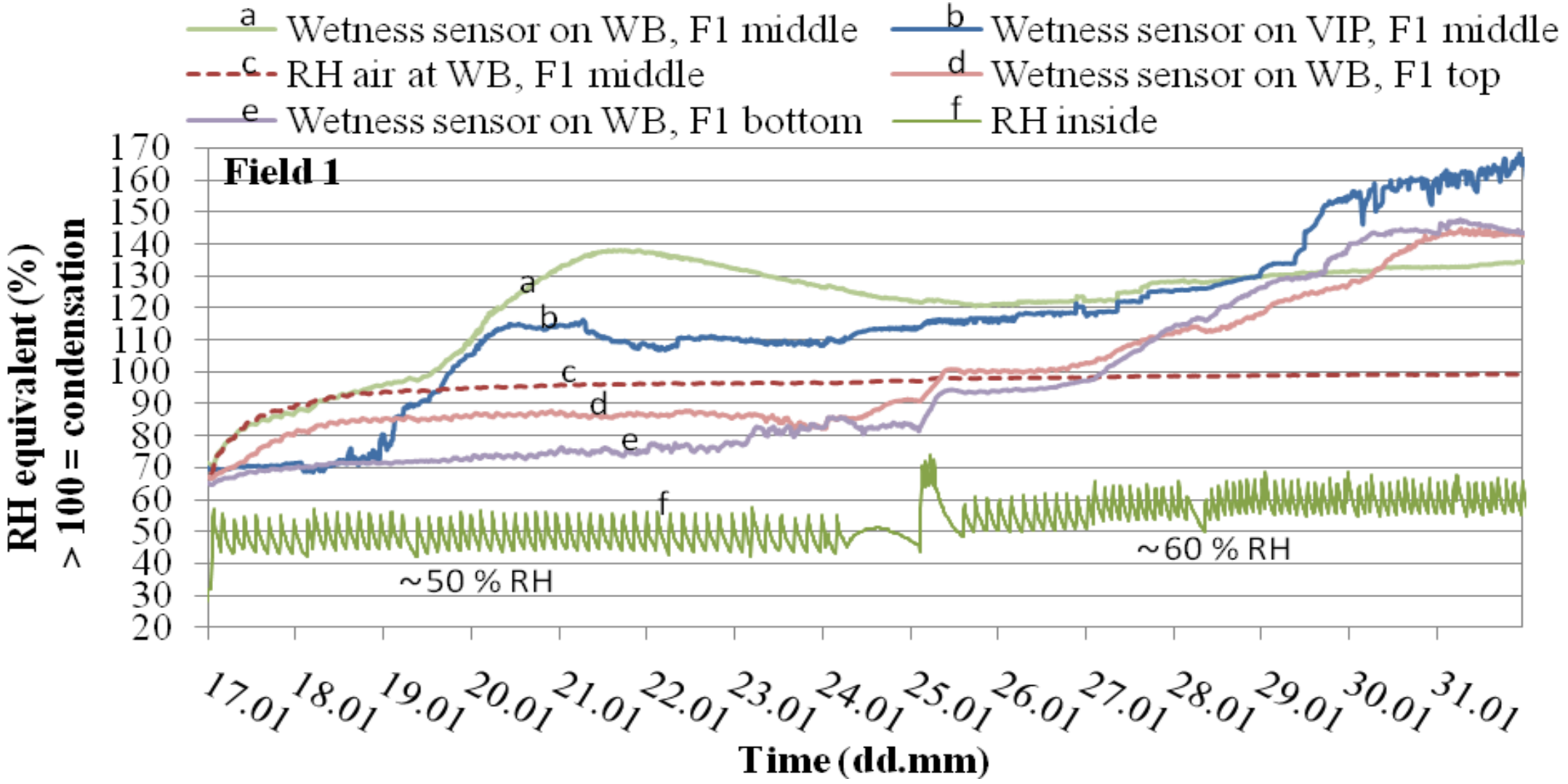


Results Wetness Sensor

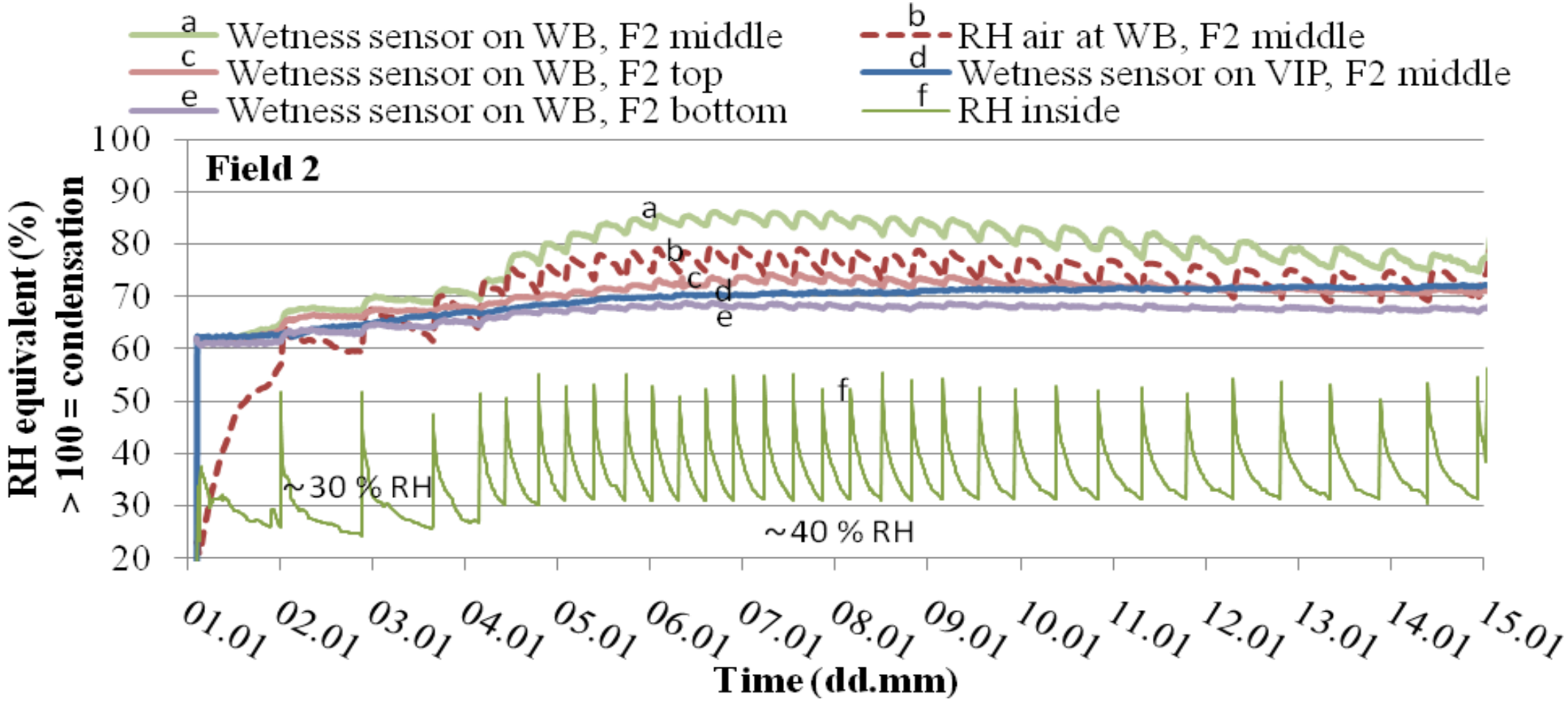
- Calibrated in a climate chamber.
- A linear connection between the calibration curve of spruce and copy paper was found (y=ax+b).
- Quite trustworthy for RH between 70 - 90 % and for condensation.

  (in good accordance with the RH air sensor)

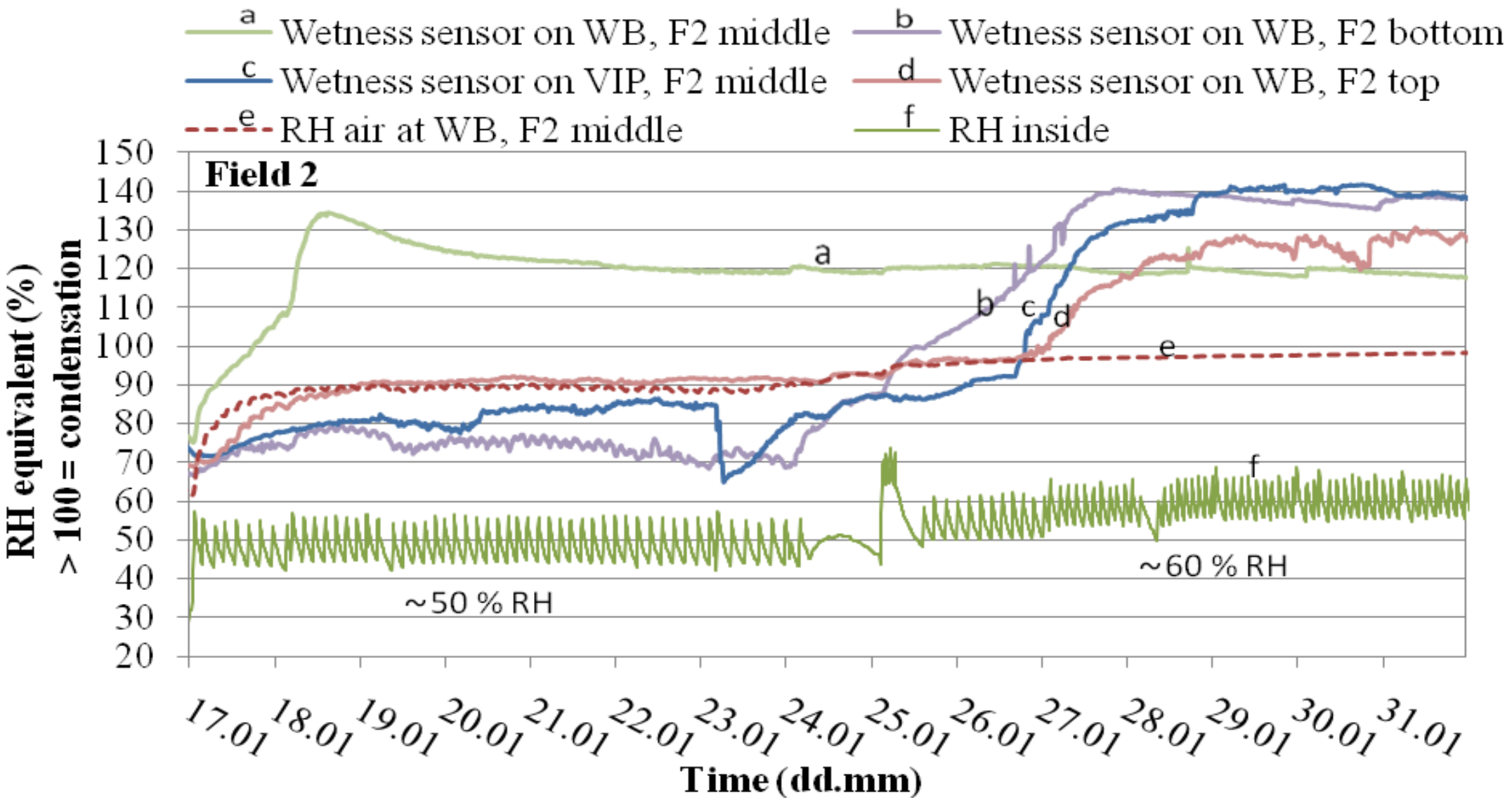
Results Field 1



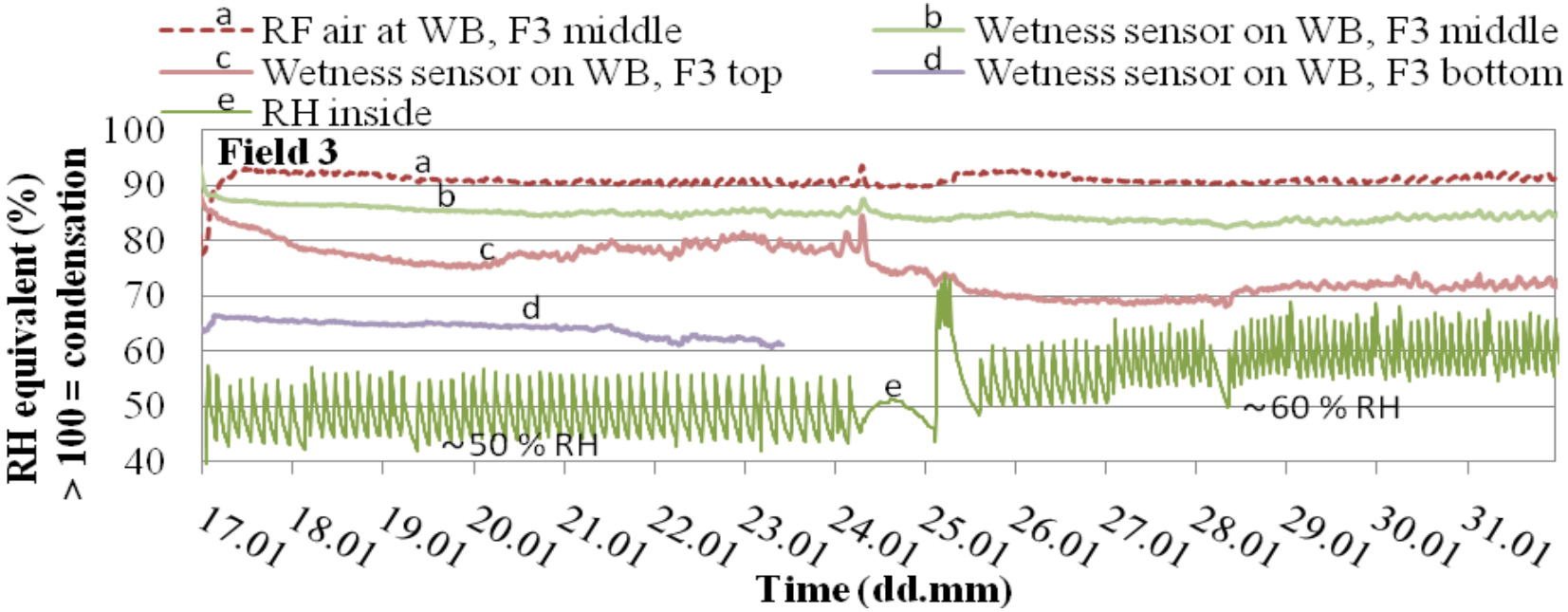
Results Field 2

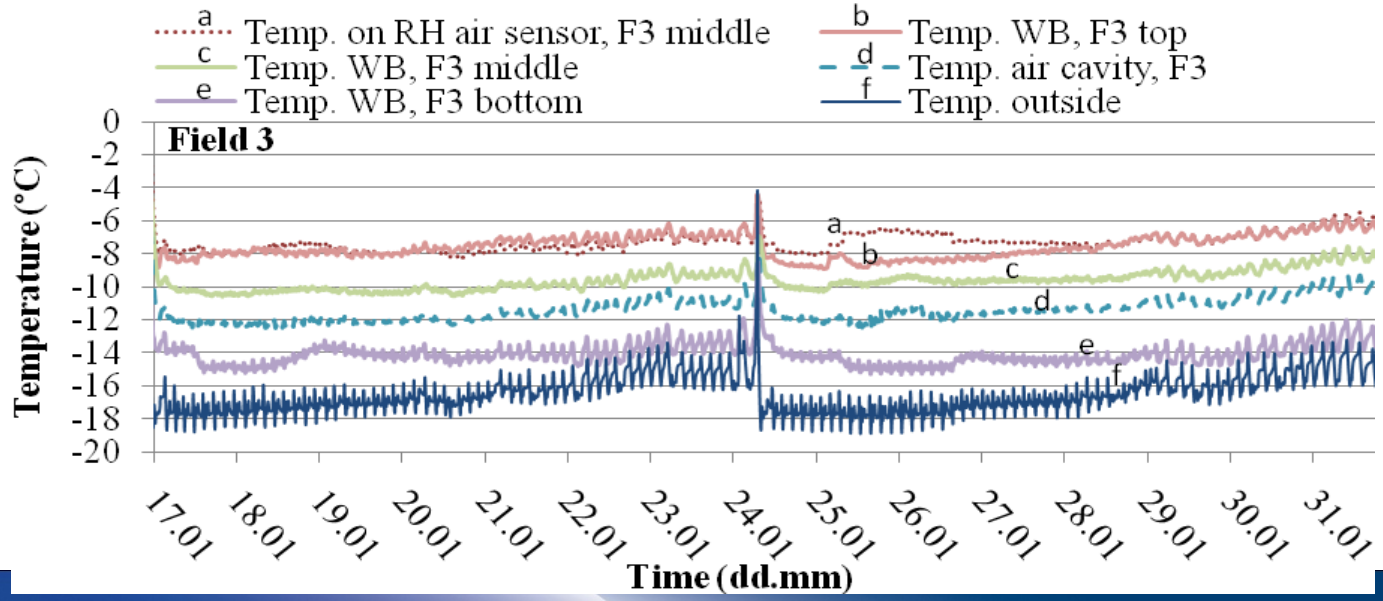


Results Field 2



Results Field 3



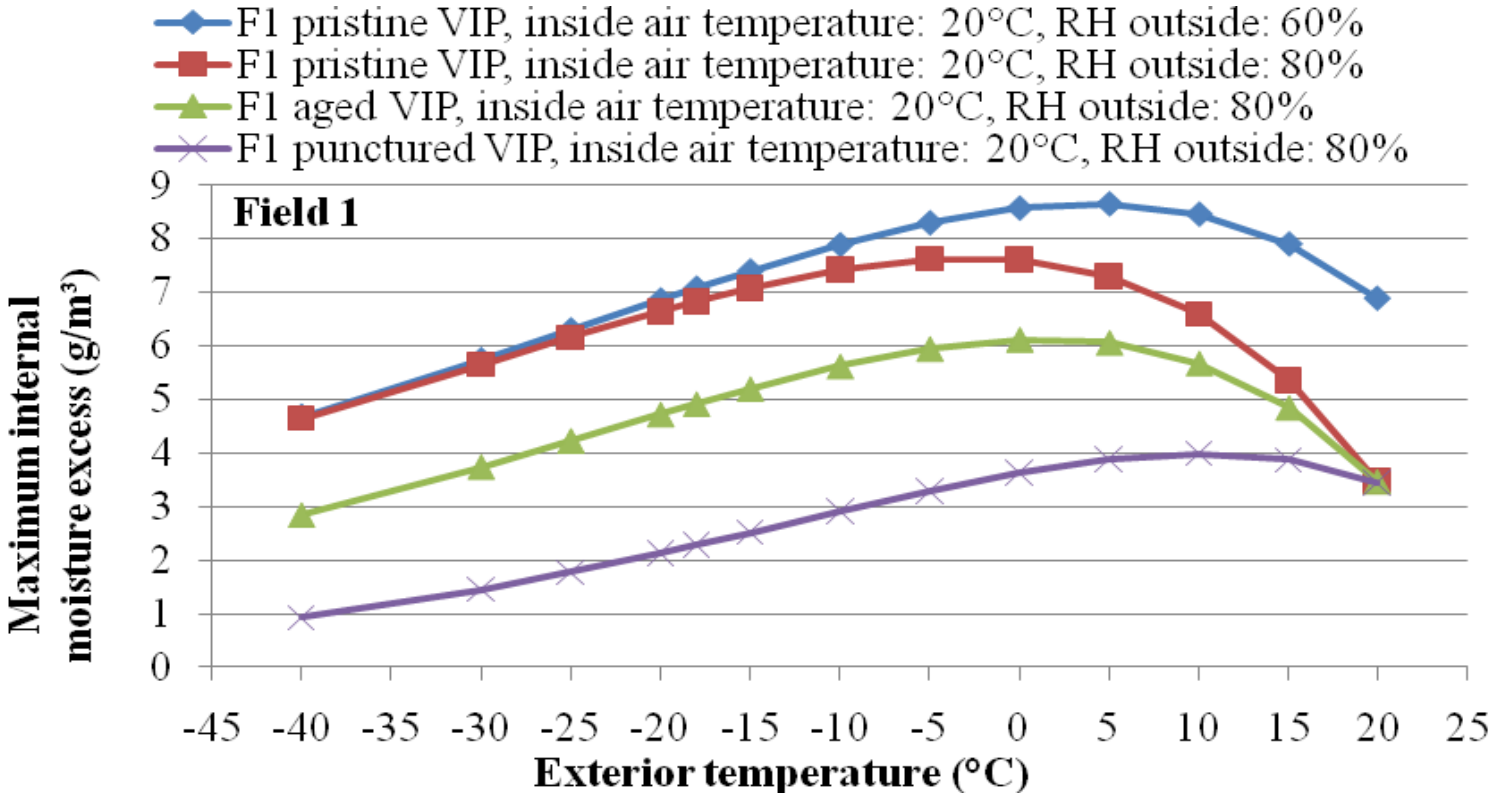


Results Field 4

- Performed well during the entire experiment.
- RH about 50 – 60 % on the wind barrier.

Limitations Provided for Avoiding Condensation

- Outdoor climate.
- Interior moisture excess.
- Interior temperature.
- Condition of the VIPs (pristine, aged, perforated).



Details and numerical simulations given in: E. Sveipe, B. P. Jelle, E. Wegger, S. Uvsløkk, S. Grynning, J. V. Thue, B. Time and A. Gustavsen, "Improving Thermal Insulation of Timber Frame Walls by Retrofitting with Vacuum Insulation Panels – Experimental and Theoretical Investigations", *Journal of Building Physics*, 35, 168-188, 2011.

Conclusions

- Laboratory investigations of VIP retrofitting of realistic sized wall fields were carried out.
- An alternative surface wetness sensor was made.
- Results show that timber frame buildings with 100 mm mineral wool may be retrofitted on the exterior side with VIPs. The results provide limitations to:
  - Outdoor climate.
  - Interior moisture excess.
  - Interior temperature.
  - Condition of VIPs (pristine, aged, perforated).

Further details given in: E. Sveipe, B. P. Jelle, E. Wegger, S. Uvsløkk, S. Grynning, J. V. Thue, B. Time and A. Gustavsen, "Improving Thermal Insulation of Timber Frame Walls by Retrofitting with Vacuum Insulation Panels – Experimental and Theoretical Investigations", *Journal of Building Physics*, 35, 168-188, 2011.

Acknowledgements

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References

R. Baetens, B. P. Jelle, J. V. Thue, M. J. Tenpierik, S. Grynning, S. Uvsløkk and A. Gustavsen, “Vacuum insulation panels for building applications: A review and beyond”, *Energy and Buildings*, **42**, 147-172, 2010.

A. Binz, A. Moosmann, G. Steinke, U. Schonhardt, F. Fregnan, H. Simmler, S. Brunner, K. Ghazi, R. Bundi, U. Heinemann, H. Schwab, J. M. Cauberg, M. J. Tenpierik, G. Johannesson, T. Thorsell, M. Erb and B. Nussbaumer, “Vacuum insulation in the building sector. Systems and applications (Subtask B)”, Final report for the IEA/ECBCS Annex 39 HiPTI-project, 2005.

EN ISO 13788, “Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods”, 2001.

Porextherm, “Vacupor NT – B2, data sheet”, http://www.porextherm.com/web/pdfdownload.htm?ID=255&doctype=PDF_EN&lang=en&externeswindow=2&ts=1270722658 (Retrieved 08.04.2010), 2009.

SINTEF 523.002, SINTEF Building Research Design Sheets no. 523.002, “Yttervegger over terreng. Egenskaper og konstruksjonsprinsipper. Krav og anbefalinger” (Exterior walls above ground. Properties and construction principles. Requirements and recommendations), SINTEF Building and Infrastructure, Norway, 2008.

Statistics Norway, “Boliger, etter bygningstype og byggeår (K)”, (Buildings, ranged by type of building and year of construction), Table 06266, 2009.

E. Sveipe, B. P. Jelle, E. Wegger, S. Uvsløkk, S. Grynning, J. V. Thue, B. Time and A. Gustavsen, ”Improving thermal insulation of timber frame walls by retrofitting with vacuum insulation panels – Experimental and theoretical investigations”, *Journal of Building Physics*, **35**, 168-188, 2011.

E. Wegger, B. P. Jelle, E. Sveipe, S. Grynning, A. Gustavsen, R. Baetens and J. V. Thue, ”Aging effects on thermal properties and service life of vacuum insulation panels”, *Journal of Building Physics*, **35**, 128-167, 2011.