Laboratory Calibration and Field Results of Wood Resistance Humidity Sensors

Kohta Ueno
Building Science Corporation

BEST 1: Building for Energy Efficiency and Durability at the Crossroads
June 10-12, 2008 Minneapolis, MN
Background

- High humidity environments in building enclosure monitoring
- Relative humidity sensor durability problems
- Relative humidity vs. capillary saturation (i.e., liquid water) resolution
- Wood moisture content-based sensor

June 10, 2008
Wood MC vs. Resistance

The graph shows the relationship between moisture content (%) and the logarithm of electrical resistance (MΩ). As moisture content increases, the logarithm of electrical resistance decreases, indicating a decrease in electrical resistance with higher moisture content.
Sorption Isotherm

- Hysteresis behavior
- Capillary range
Sensor Type: “Wafer”

- Brass pin
- Pin spacing 25.0
- Face view
- Edge view
- Signal +12 V
- 35.0
- Installation at planar interface
Sensor Type: “Plug”

- Installation in drilled hole in masonry or concrete

Diagram showing:
- Brass pin
- Brass ring
- Urethane caulk
- Signal +12 V
- Epoxy end cap (optional)
- Heat shrink tubing

Dimensions:
- 29.0
- 9.5

Images of the Sensor Type: “Plug”
Laboratory Calibration

- Start: 66°F/50% RH test facility
- Step change to 100% RH chamber
- Return to 50% RH
Wafer Laboratory Calibration: Adsorption (Wetting)

- Time constant curve fit ($\tau = 24$ hrs)
- Representative "plug" sensor response

Identical response out to 900+ hours
Wafer Laboratory Calibration: Desorption (Drying)

- Desorption response much faster than adsorption response.
Laboratory Calibration: Immersion Testing

- Sensor can distinguish between high humidity & liquid water
- Less certain of absolute moisture content at high range
Resistance vs. Gravimetric Time Response
Resistance vs. Gravimetric Time Response

Moisture content (%, Gravimetric)

Hours

Resistance Comparison
Resistance vs. Gravimetric Time Response

- Electrical resistance measurements accurately reflect gravimetric adsorption/desorption time response
Hygrothermal Simulations

- Replicate asymmetric wetting vs. drying behavior in simulation?
Hygrothermal Simulations

- Which material property critical?

- IBP = asymmetric
- NTNU = symmetric

![Graph showing moisture content (kg/m^3) against relative humidity (%). The graph compares Softwood IBP and NTNU Pine.](chart.png)
Field Measurements: Brick Cavity Space
Field Measurements: Brick Cavity Space

- 90-100% RH from October-May (typical)
- 40-60% RH summer (South)
- ~80% RH summer (North)
- Many RH sensor failures (intermittent data, 4 of 6 survived)

- Wafer sensors showed similar seasonal pattern
- Wafer sensors returned consistent data throughout
Field Measurements: Brick Cavity Space

- North 1
- North 2
- North 3
- South 1
- South 2
- +5% RH
- -5% RH

Sorption isotherm
Field Measurements: Basement Wall Insulation
Field Measurements: Basement Wall Insulation

- FG-Latex Interface
- XPS Interface
- Poly-Frame Interface
- Roll Blanket Interface
- Isotherm
- +5% RH
- -5% RH
Field Measurements: Inward Vapor Drive Condensation
Field Measurements: Inward Vapor Drive Condensation

- Six walls (3 N/3 S)
- 1” XPS & 2x4
- OSB & 2x6 (polyethylene)
- OSB & 2x6 (no poly)
Field Measurements: Inward Vapor Drive Condensation

![Graph showing moisture content over time for North XPS, South XPS, North No Poly, South No Poly, North Poly, South Poly, and Exterior T. The graph includes moisture content (%), temperature (F), and dates from 1/06 to 12/06. The graph indicates periods of condensation and the impact of interior and exterior conditions.]
Field Measurements: Inward Vapor Drive Condensation
Field Measurements: Masonry Veneer Wall
Field Measurements: Masonry Veneer Wall

Graph showing moisture content (%) and temperature (°C) over time from 11/15/05 to 7/8/07 for different materials and conditions.
Conclusions

- 100% RH ≈ 27-32% MC
- Liquid water condensation as distinct response vs. 100% RH
- Field installation ±10% RH or better, ±5% RH typical
- Slow wetting response, fast drying
- Use for longer-term (e.g., seasonal) measurements, not diurnal
- Good reliability in field installations
Acknowledgements

U.S. Department of Energy Building America Program

Canada Mortgage & Housing Corporation
Resources

- This presentation will be at
  - www.BuildingScienceSeminars.com
- Much more free downloadable info at
  - www.BuildingScience.com
Plug Laboratory Calibration: Concrete Cylinder Uptake
Plug Laboratory Calibration: Concrete Cylinder Uptake

- Demonstrates slow adsorption response
- Indicates 100% RH (not liquid water capillarity) here