Causes of High Relative Humidity Inside Air Conditioned Buildings

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S. FLORIDA – AVE. AMBIENT 91 F dB / 78 F wB

16,000 HOURS ANNUALLY THAT wB ≥ 66 F

THIS INDICATES A SIGNIFICANT PROBLEM WITH HIGH OUTDOOR HUMIDITY AND THEREFORE, HIGH INDOOR HUMIDITY
South Florida Summer Outside Conditions

- Temperature (°F)
- RH (%)
Cause of High Relative Humidity Inside Air Conditioned Buildings

Study Included:

• HVAC Equipment Diagnosis
• Heat Gain Calculations
• Field survey and logging of Temperature, RH and Occupant Interviews
• Maintenance / Mechanical Evaluations
Study Parameters

- Forty-One (41) Schools Investigated
  - 228 Separate Air-Conditioned Buildings
  - 28 Elementary (ES), 7 Middle (MS), 3 High Schools (HS) & 3 Vocational Centers (Ctr)
  - 1036 HVAC Systems:
    631 Air Handling Units (AHU), 283 Fan Coil Units (FCU), 90 Unit Ventilators (UV) & 32 Heat Pumps (HP)
Study Results

• After occupant interview, data logging was performed using HOBO™ H8 loggers for RH/Temp for one week.
• The logging and occupant interviews were followed up with detailed maintenance and mechanical assessments.
• A summary report which analyzed findings included a detail of the cause(s) of high RH.
Causes of High Relative Humidity Inside Air Conditioned Buildings

Controls Which Affected Relative Humidity

– 63 % had Malfunctioning or Misapplied Dehumidification Enhancements – Face & Bypass, Supply Bypass etc.

– 93 % had a potential for uncontrolled humidity entering spaces through the lack of Outside Air Controls – Building Pressurization, Manual Dampers only, Exhaust Fans on 24 hrs.
Age of Equipment and Maintenance

- HVAC Equipment Service Life (ASHRAE Recommendation ~ 20 years)
- 30% - 20 years or the age was unknown
- 13% - 15-20 years
- 53% - 5-15 years
- 4% - 0-5 years
Commercial Dehumidification

• Commercial systems dehumidify by chilling air below the dew point
• Water condenses out on the fins of the cooling coil
• The leaving air has a reduced dew point and specific humidity
• The leaving air will be saturated and should have a relative humidity of about 100%
Chilled Water System

CHILLED WATER SYSTEM

CHILLER

Compressor

Hot Vapor

Heat Exchanger

Vapor

Warm Water

Cooled Water

Conditioned Air

Fan

Warm Water 52°

50°

Chilled Water
Causes of High Relative Humidity

More Outside Air Than Capacity of System

• Negatively Pressurized Building and/or Cavities – 140 cases (21.41%)
• Excessive or Uncontrolled Ventilation - 129 cases (19.72%)
• Oversized Units – 118 cases (11.47%)
• Partial Load with High Relative Humidity -- 85 cases (8%)
Face and By-Pass

SUPPLY
AIR

COOLING
COIL

BYPASS
DAMPER

RETURN
AIR

FRESH
AIR

BYPASS
DAMPER
11 Middle School - Building 2, Lab Storage 241 (AHU - 1)

LAB HOOD OPERATION CAUSES NEGATIVE PRESSURE CONDITION WHICH LEADS TO HIGH RELATIVE HUMIDITY

Temperature (°F) c:1
RH (%) c:12
Coil Capacity Inadequate

- **Coil Too Warm During Partial Load Conditions (14.53%)**
  - Coil inadequate for latent loads (too few rows)
  - Frequently due to excessive outside air
  - Stratification of air through coil
COIL TEMPERATURE AND VARIABLE AIR VOLUME LEADS TO HIGH RELATIVE HUMIDITY
Temperature Controls That Caused RH Problems

• Modulating Chilled Water Valve (11.93%)
  – Constant Ventilation with Continuous Fan Operation and Cycling Cooling
  – Chilled Water Reset
MODULATING CHILLED WATER VALVES WITH LOW TEMPERATURE SET POINT ALLOW HIGH RELATIVE HUMIDITY
03 Elementary School - Building 2, Classroom 242 (AHU - 1)

MODULATING CHILLED WATER VALVES LEAD TO HIGH COIL TEMPERATURE AND EXCESS RELATIVE HUMIDITY
Correct Lack of Coil Capacity

- Replace Coil
- Precondition outside air
- Eliminate Chilled Water Reset
- Replace modulated CW valves with on-off valves
- Install dehumidification enhancing features
Exhaust Fans On 24 Hrs

Building envelope
EXHAUST FANS RUN IN PM AND LEAD TO HIGH RELATIVE HUMIDITY
Condition Outside Air

Intentional opening
No dampers to shut down the OA intakes
Positively Pressurize Building

• Precondition fresh air 10% greater than exhaust air
• Avoid plenum returns – use ducted returns
• Avoid supply ducts in unconditioned attics
• Seal wall cavities from ceiling plenum
• Use PM automatic damper controls
Special Cases:

- Fan Coil Units with Filter Grille
- Unit Ventilators
09 Elementary School - Building 1, Classroom 138 (UV - 4)

UNIT VENTILATOR FACE AND BYPASS IS INEFFECTIVE FOR CLIMATE AND LEADS TO HIGH RELATIVE HUMIDITY
ASHRAE – Environmental and Ventilation Requirements


Findings from Study

ASHRAE ‘Compliance’

• 25 of 41 schools studied had HVAC equipment installed with a capacity of 5 CFM OA / person
• 3 of 41 schools had HVAC equipment installed with 15 CFM OA / person
• 13 schools had mixed capacity when new additions were made
Findings from Study

High Relative Humidity

- Analysis of Relative Humidity and Temperature Logs proved to be a powerful tool
- Misapplied or Malfunctioning Dehumidification Enhancement to HVAC Equipment often led to high Relative Humidity
- The lack of Outdoor Air Control appeared to be the most consistent cause of high RH either in conjunction with mechanical issues or separately
Recommendations for Future Study

• IEQ Conditions with ventilation for occupants at 5 CFM / person
• Maintenance and Retrofit of HVAC Equipment
• Building Envelope contribution to Relative Humidity
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