New Opportunities For Spray Polyurethane Foam

Presented by:

Len Anastasi

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Recent Building Code Changes

2006 International Energy Code

Increases insulation requirements for buildings

Requires continuous insulation to the exterior of the exterior sheathing
Recent Building Code Changes

2009 International Energy Code

Increases insulation requirements for buildings

Requires continuous insulation to the exterior of the exterior sheathing
Recent Building Standards Changes

ASHRAE 90.1 2010

Requires air barriers in most buildings

Requires continuous insulation to the exterior of the exterior sheathing

Sets forth calculations determining R-Values of wall assemblies and factors in thermal bridging
Recent Building Code Changes

2012 International Energy Code

Requires air barriers on most buildings
Recent Building Standards Changes

U. S. Green Building Council

Proposed new LEED Certification Requirements require compliance with ASHRAE 90.1-2010 which requires air barriers on most buildings
Why are these changes being adopted???

Better Performing Walls!!

These walls now have greater thermal transfer resistance

These walls now deal with the four wetting potentials much more effectively
The Wetting Potentials

- Liquid Water Ingress (Water Barrier)
- Moisture Transport Due To Air Flow (Air Barrier)
- Dew Point (Heat Barrier Location)
- Vapor Migration (Vapor Barrier)
How Do We Properly Deal With These Four Wetting Potentials???

Good HAMM!!!
What the #$& is HAMM?

• HAMM is the 4 barriers needed to protect a building against the effects of weather. These barriers are:

H  Heat Barrier
A  Air Barrier
M_L  Water Barrier (Liquid Moisture)
M_V  Vapor Barrier (Gaseous Moisture)

HAMM is the WEATHER BARRIER SYSTEM
Hamm Order Of Magnitude

\( M_L \)  Water Barrier (Liquid Moisture)

\( A \)  Air Barrier

\( H \)  Heat Barrier

\( M_V \)  Vapor Barrier (Gaseous Moisture)
THE WATER BARRIER

• Resists the intrusion of moisture in its liquid form (water) into and through the building enclosure system.

• Over the history of Building Enclosure System use, water barriers have been:
  - Ineffective due to their inability to resist water penetration.
  - Ineffective due to improper installation.
  - Ineffective due to lack of longevity.

• If an air barrier is properly designed and installed in a building enclosure system and the air barrier material is also a water barrier, won’t the past deficiencies of water barrier be resolved?
Is this an effective water barrier?
Is this an effective water barrier???
Is this an effective water barrier???
THE AIR BARRIER

Air Barrier System (ABS): A system of building components within the building enclosure system (BES) designed and installed in such a manner as to stop the flow of air into and out of buildings through the BES.
Air Barrier Systems

For the life of your building

by Leonard Anastasi, CSI

In the past decade, the use of air barrier systems (ABSs) in the building envelope has been steadily increasing because they have been proven to increase energy efficiency, reduce the potential for envelope system failures, and reduce the occurrence of indoor air quality (IAQ) problems.

To date, ABSs have primarily been included in envelopes for "high-performance," "high-end" buildings, such as field or pool houses, museum storage facilities, and "monumental" buildings. However, research into the theory, science, and performance of ABSs has significantly increased in this country to the point where their advantages are significant in virtually all buildings.

The U.S. Department of Energy (DOE) has concluded that up to 40 percent of the energy required to heat and cool a building is wasted through uncontrolled air movement. As such, building owners can expect substantial savings in their heating and cooling costs. ABS can also eliminate the occurrence of building envelope system failures caused by moisture infiltrating the system. Moisture corrodes metals and decreases the thermal performance of insulation.

Air flow has the ability to transport exponentially more moisture into and through building envelopes than can be transferred through vapor migration. By stopping the flow of air through the building envelope, the flow of moisture is virtually halted, and by reducing moisture, one can also eliminate many of the conditions under which mold and fungi grow. These biological agents are a major concern for building professionals due to the effects they have on both IAQ and the health of building occupants.

The incorporation of ABS in new construction is not a passing fad. The state of Massachusetts, for example, implemented legislation this year requiring air barrier systems in all commercial buildings and certain multi-tenant buildings over 929 m² (10,000 ft²)—and they are not alone. Currently, 21 states are considering incorporating ABSs in their building codes.

The real deal

Many in the construction industry do not know what an ABS is, nor what it does. The most succinct definition was penned by Lance Robine Jr. of Building Envelope Technologies, Inc., for the Air Barrier Association of America (ABAA): 'A combination of building envelope components designed and installed in such a manner as to control the infiltration and exfiltration of air through the building envelope.'
Why stop the flow of air into and through the BES?

First and foremost...........

1.) Air flow has the ability to transport exponentially more moisture into and through the building enclosure system than occurs through vapor migration or diffusion. Estimates range from 30 to 200 times more moisture transport occurs via air flow than vapor migration.
Excess moisture in exterior walls causes:

Corrosion of metal items
Excess moisture in exterior walls causes:

Photo of mold in wall. Photo supplied courtesy of Canadian Home Builders' Association (CHBA) and Canadian Mortgage and Housing Corp. (CMHC)

The “M” Word
Excess moisture in exterior walls causes:

Crumbling masonry
Excess moisture in exterior walls causes:

Efflorescence
2.) Air flow into and out of buildings can affect the location of the dew point.

3.) Air leakage into and out of buildings causes the HVAC system to expend extraneous energy in order to maintain the building’s desired temperature and humidity levels.

4.) Air flow is a vehicle by which sound travels.

5.) Air flow is a vehicle by which particulate matter travels.

6.) Air flow is a vehicle by which odors and gaseous substances travel.
Why use Air Barrier Systems?

The use of Air Barrier Systems result in:

- Reduced Building Enclosure System problems
- Wetting potentials effectively dealt with
- Improved indoor air quality
- Reduced building energy consumption
- Reduced building heating and cooling costs
- Reduced fossil fuel consumption
- Reduced pollution emissions
- Reduction of the Greenhouse Effect
Is this an effective air barrier???
The Dew Point

The dew point is the temperature at which air that contains a certain amount of vapor can no longer hold that vapor and must exhaust itself of excess vapor by depositing it on adjacent surfaces in the form of condensation (water).
Where does the water on the outside of the glass come from?
The dew point is the temperature at which condensation forms on condensing surfaces. When air comes into contact with a surface that is at or below the dew point temperature of that air, condensation will form on it.

EXAMPLE 1: If the interior air temperature is 70° F and has an RH of 30%, the infiltration of air that is 37° F (the dew point temperature) can cool condensing surfaces to this temperature (37°) causing dew to form on these surfaces.

EXAMPLE 2: If exterior air with a temperature of 85° F and an RH of 70% infiltrates into the building envelope, dew will form on condensing surfaces in the system that have temperatures of 74° F or less.
How much moisture gets in via air transport?

This value cannot be accurately calculated due to the fact that both the direction and rate of air flow into and through the BES can change dramatically on as little as a minute to minute basis. More importantly, the amount of moisture created due to condensation of this flowing air cannot be accurately calculated, predicted or accounted for.

Highly advanced computer modeling programs exist to analyze vapor transport, thermal performance, hygric capacity and drying times of exterior walls. Not one of them can account for the transport of moisture via air flow.
THE HEAT BARRIER

- Resists thermal transfer through the building enclosure system.
  - R-Value is the measure of resistance to thermal transfer.
  - The higher the R-Value, the greater the resistance.
  - The greater the resistance, the lower the heat gain / loss.

- The location of the heat barrier, in a properly designed and constructed building enclosure system, determines the location of the dew point.
THE HEAT BARRIER

Second Law Of Thermodynamics

“ The entropy of an isolated system which is not in equilibrium will tend to increase over time, approaching a maximum value at equilibrium. “

Translation anyone???

Heat seeks cold!!!
THERMAL PERFORMANCE

Factors affecting thermal performance of insulation

- Air leakage through gaps in the insulation
- Wind wash effect on fibrous insulation
- Thermal Bridging
New Whole Wall R-value Calculators As A Part Of The ORNL Material Database For Whole Building Energy Simulations

These calculators are replacing the old Whole Wall Thermal Performance calculator. These new versions of the calculator contain many new features and are part of the newly developed Interactive Envelope Materials Database for Whole-Building Energy Simulation Programs.

The simple version of the Whole Wall R-value calculator is now available for use. This calculator is similar to the previous Whole Wall Thermal Performance calculator and does not require any downloads from the user. However, it was updated to allow calculations for fourteen wall details instead of nine. It simply runs over the Internet. Use this calculator for whole wall R-value calculations and for direct comparisons of different wall technologies. This calculator uses a residential building containing a rectangle slab-on-grade foundation with one floor containing a set amount of windows and doors. A link is available for detailed specifications of the example building.

***** UPATDATE 08-30-05 *****

New Whole Wall R-value Calculator 2.0 Available For Download

http://www.ornl.gov/sci/roofs+walls/AWT/home.htm
THERMAL BRIDGING

What is the R-Value of a 6” LGMF wall with R-19 batts insulation, exterior gypsum sheathing and interior gypsum wallboard?

R 7.2
Is this an effective heat barrier???
Vapor barriers are materials used in Building Enclosure Systems to retard the diffusion of vapor into and through the building enclosure system.

**Why Are Vapor Barriers Needed?**

By retarding the diffusion of vapor through the Building Enclosure System, conditions that create dew points within Building Enclosure Systems can be reduced or prevented and interior RH levels can be maintained.
What Is Vapor Diffusion?

Vapor diffusion is the process by which vapor seeks to equalize its content between different environments (the Ideal Gas Law).

The driving force (or “potential”) for this occurrence is vapor pressure.

Vapor pressure is a function of the vapor content of the air (RH) and the temperature.

Vapor diffusion is caused by a vapor pressure differential ($\Delta P$) between different environments. The greater the $\Delta P$ between environments, the greater the amount of vapor diffusion that occurs.
Table 1. VAPOUR PRESSURE FOR VARIOUS TEMPERATURES AND RELATIVE HUMIDITIES (POUNDS PER SQUARE INCH).

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Is this an effective vapor barrier???
THE DYSFUNCTIONAL BUILDING ENCLOSURE SYSTEM

VENEER (PROTECTIVE LAYER)

CAVITY (DRAINAGE SPACE)

WATER RESISTANT BARRIER
(DRAINAGE PLANE)

FIBERGLASS BATTs INSULATION
(HEAT BARRIER)

LG MF & GWB (STRUCTURAL LAYER)

VAPOR BARRIER ???

BRICK VENEER IS A “RESEVOIR” CLADDING MATERIAL. IT WILL HOLD MOISTURE AND WHEN HEATED BY SOLAR RADIATION, WILL CREATE EXTREME TEMPERATURES AND VAPOR PRESSURE LEVELS IN THE CAVITY SPACE.

GWB SHEATHING IS NOT PROTECTED FROM MOISTURE INTRUSION IN ITS GASEOUS FORM.

GWB ABSORBS AND RETAINS MOISTURE AND WILL DEGRade OR DETERIORATE UNDER FAIRLY LOW MOISTURE CONTENT LEVELS AS WELL AS HOST MICROBIAL GROWTH.

LG MF SYSTEMS WITH GWB AND VAPOR BARRIERS CREATE CHAMBERS FROM WHICH VAPOR CANNOT BE EASILY VENTED.

LG MF MEMBERS WILL CORRODE WHEN EXPOSED HIGH RH LEVELS.

DEW POINT RANGE

INTERIOR
HEATED, COOLED AND HUMIDITY CONTROLLED ENVIRONMENT
COLD CLIMATE

EXTERIOR AIR
30°F
30% RH
VP = 0.024 psi

HVAC SYSTEM

MOISTURE ADDED TO AIR IN THE HVAC SYSTEM TO ACHIEVE DESIRED INTERIOR RH LEVELS.

INTERIOR AIR
70°F
RH LEVELS
OFFICES 30%
APTS 30%
SCHOOLS 30%
HOTELS 30%
LIBRARIES 50%
MUSEUMS 50%
LABS 30%-50%
POOL HOUSES 80%
VP = 0.108 to 0.290

THEORETICAL DEW POINT

WATER INTRUSION

VAPOR TRANSPORT DUE TO AIR FLOW

HEAT LOSS

VAPOR MIGRATION

AIR FLOW CAN CHANGE THE LOCATION OF THE DEW POINT.

ANOverview of moisture management in a cold climate. The exterior air is at 30°F with 30% RH and a vapor pressure of 0.024 psi. The HVAC system adds moisture to the interior air to achieve desired RH levels, ranging from 30% to 50% in various settings. Interior air is at 70°F, and RH levels vary depending on the location. Heat loss and water intrusion are also illustrated, with air flow changing the location of the dew point.
WARM CLIMATE

EXTERIOR AIR
90° F
80% RH
VP = 0.558 psi

HVAC SYSTEM

DEW POINT TEMPERATURE REACHED IN THE HVAC CHILLER. CONDENSATION IS COLLECTED AND DRAINED AWAY.

INTERIOR AIR
70° F
RH LEVELS
OFFICES 50%
APTS 50%
SCHOOLS 50%
HOTELS 50%
LIBRARIES 50%
MUSEUMS 50%
LABS 30%-80%
POOL HOUSES 80%
VP = 0.108 to 0.290

VIRTUAL DEW POINT

WATER INTRUSION

VAPOR TRANSPORT DUE TO AIR FLOW

THEORETICAL DEW POINT

HEAT GAIN

VAPOR MIGRATION

BRICK AND CAVITY AIR UNDER SOLAR EXPOSURE
120° F  90% RH

AIR FLOW CAN CHANGE THE LOCATION OF THE DEW POINT
Cold Climate Air And Vapor Barrier System: Winter

**EXTERIOR AIR**
- 30°F
- 30% RH

**WATER INTRUSION**

**WIND AND NEGATIVE STACK PRESSURE**

**FAN AND POSITIVE STACK PRESSURE**

**THERMAL BRIDGING DOES NOT OCCUR DUE TO CONTINUITY OF THE HEAT BARRIER**

**A DEW POINT DOES NOT OCCUR WITHIN THE BES DUE TO AN EFFECTIVE VAPOR BARRIER**

**HEAT LOSS**

**VAPOR MIGRATION**

**INTERIOR AIR**
- 70°F
- 30% RH
Cold Climate Air And Vapor Barrier System: Summer

EXTERIOR AIR
90° F
80% RH

WATER INTRUSION

WIND AND NEGATIVE STACK PRESSURE

HEAT GAIN

VAPOR MIGRATION

Dew point

THE DEW POINT OCCURS WITHIN HEAT BARRIER WHICH IS TO THE EXTERIOR OF THE DRAINAGE PLANE.

NOT A PROBLEM!!!

FAN AND POSITIVE STACK PRESSURE

INTERIOR AIR
70° F
30% RH
2 lb Density Closed-Cell Spray Polyurethane Foam

H  Seamless Heat Barrier
A  Seamless Air Barrier
ML Seamless Water Barrier
MV Seamless Vapor Barrier

All in one product, installed by one contractor and in one location.
Everett High School Everett, MA

HEAT BARRIER, AIR BARRIER, WATER BARRIER & VAPOR RETARDER
Everett High School Everett, MA

HEAT BARRIER, AIR BARRIER, WATER BARRIER & VAPOR RETARDER
University of Vermont Burlington, VT

HEAT BARRIER, AIR BARRIER, WATER BARRIER & VAPOR RETARDER

08/31/2006
Wyndham High School Wyndham, NH

HEAT BARRIER, AIR BARRIER, WATER BARRIER & VAPOR RETARDER

05/01/2008
IEC Insulation Requirements

2006
Most states have adopted or are adopting now

2009
Will be adopted by most states over the next five years
### Building Envelope Requirements - Opaque Assemblies

#### Roofs

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<th>3</th>
<th>Marine</th>
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#### Walls, Above Grade

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<th>3</th>
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#### Walls, Below Grade

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<td>R-7.5ci</td>
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#### Floors

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#### Slab-on-Grade Floors

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<tr>
<td>Heated slabs</td>
<td>R-7.5 for 12 in. below</td>
<td>R-7.5 for 12 in. below</td>
<td>R-7.5 for 12 in. below</td>
<td>R-7.5 for 12 in. below</td>
<td>R-7.5 for 36 in. below</td>
<td>R-10 for 36 in. below</td>
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#### Opaque Doors

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<td>Swinging</td>
<td>U-0.7</td>
<td>U-0.7</td>
<td>U-0.7</td>
<td>U-0.7</td>
<td>U-0.7</td>
<td>U-0.7</td>
<td>U-0.7</td>
<td>U-0.5</td>
</tr>
<tr>
<td>Roll-up or sliding</td>
<td>U-1.45</td>
<td>U-1.45</td>
<td>U-1.45</td>
<td>U-1.45</td>
<td>U-0.5</td>
<td>U-0.5</td>
<td>U-0.5</td>
<td>U-0.5</td>
</tr>
</tbody>
</table>

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a. Thermal blocks are a minimum R - 5 of rigid insulation, which extends 1-inch beyond the width of the purlin on each side, perpendicular to the purlin.
b. Assembly descriptions can be found in Table 502.2
c. R - 5.7ci may be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-in. /h·f·F.
d. When heated slabs are placed below grade, below grade walls must meet the exterior insulation requirements.
e. Insulation is not required for mass walls in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B.
# Building Envelope Requirements - Opaque Assemblies

**Source:** IECC 2009 TABLE 502.2(1)

### Table: Building Envelope Requirements - Opaque Assemblies

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 and Marine-4</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attic and other</td>
<td>R-30</td>
<td>R-38</td>
<td>R-38</td>
<td>R-38</td>
<td>R-38</td>
<td>R-38</td>
<td>R-38</td>
<td>R-49</td>
</tr>
<tr>
<td><strong>Walls, Above Grade</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal building</td>
<td>R-16</td>
<td>R-16</td>
<td>R-19</td>
<td>R-19</td>
<td>R-13 + R-5.6ci</td>
<td>R-13 + R-5.6ci</td>
<td>R-13 + R-5.6ci</td>
<td>R-13 + R-5.6ci</td>
</tr>
<tr>
<td>Metal framed</td>
<td>R-13</td>
<td>R-13</td>
<td>R-13</td>
<td>R-13 + R-7.5ci</td>
<td>R-13 + R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
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<tr>
<td>Wood framed and other</td>
<td>R-13</td>
<td>R-13</td>
<td>R-13</td>
<td>R-13 + R-3.8ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-15.6ci</td>
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<tr>
<td><strong>Walls, Below Grade</strong></td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Below grade wall</td>
<td>NR</td>
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<td>NR</td>
<td>NR</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
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<tr>
<td>Mass</td>
<td>NR</td>
<td>R-6.3ci</td>
<td>R-6.3ci</td>
<td>R-10ci</td>
<td>R-10ci</td>
<td>R-12.5ci</td>
<td>R-15ci</td>
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</tr>
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<td>Joist/Framing</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>R-19</td>
<td>R-19</td>
<td>R-30</td>
<td>R-30</td>
</tr>
<tr>
<td><strong>Slab-on-Grade Floors</strong></td>
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<tr>
<td><strong>Opaque Doors</strong></td>
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</tr>
</tbody>
</table>

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a. When using R-value compliance method, a thermal spacer block is required, otherwise use the U-factor compliance method. (see Tables 502.1.2 and 502.2(2))

b. Assembly descriptions can be found in Table 502.2(2)

c. R-5.7 ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores

d. When heated slabs are placed below grade, below-grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.

e. Steel floor joist systems shall to be R-38.
ACI 503

4 1/2"
BIA Tech Notes

1” Minimum …… 2” Recommended
SPF In Cavity

3” of 2 lb Density Closed-Cell SPF ( R-6.7 / inch thickness )

= R-20.1

Leaves 1 1/2” cavity

Meets or exceeds 2006 & 2009 IEC Requirements for metal framed above grade walls in all climate zones
Good applicators can control the thickness
XPS In Cavity

3 1/2” XPS in cavity
= R-17.5 ( R-5 / inch thickness )

Leaves 1” cavity

Does not meet 2009 IEC Requirements for zones 4 thru 8 for metal framed buildings

Multiple layer installation
( 2” + 1 1/2 “ )
3 1/2” EPS in cavity
= R-10 ( R-4 / inch thickness )

Leaves 1” cavity

Does not meet 2006 or 2009 Requirements for zones 1 thru 8 for metal framed buildings

Multiple layer installation
( 2” + 1 1/2” )
Rock or Mineral Wool In Cavity

3 1/2” mineral wool in cavity
= R-14.7 ( R-4.2 / inch thickness )

Leaves 1” cavity

Does not meet 2006 or 2009 Requirements for zones 4 thru 8 for metal framed buildings

Multiple layer installation
If you start introducing insulation to the interior side of the exterior sheathing, you start having to deal with a new wetting and drying potentials.

In many cases, it becomes a problem!!!
2 lb Density Closed-Cell Spray Polyurethane Foam

The **ONLY** answer for precast concrete panel veneers
Fibrous Insulation On Precast Results In Condensation Problems
Questions?