Weatherization and Retrofits

Retrofits in 2011 and Beyond
The first question is Why retrofit an existing building?

- Reduce operating cost
- Improve comfort
- Improve durability
- Lessen impact on our environment
  - Reduce fossil fuel use
  - Reduce the carbon footprint
- National Security
  - Reduce need to import foreign oil
Why is the Retrofit Market Important?

39% of our Nation’s energy use is from building operations.
Why is the Retrofit Market Important?

42% of Residential and 29% of Commercial energy use is HVAC.
Why is the Retro Market important?

- Increased energy efficiency in new construction only decreases the overall increase in energy used nationally.
Why is the Retro Market important?

- The only way we can hope to use less energy and produce less CO2 in the US is to insulate and air-seal our Built Environment.
How big is the Retro Market?

New Construction vs. Retrofit

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Housing Starts</th>
<th>Total Closings</th>
<th>Customer Base Comparison</th>
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<td>2010</td>
<td>587,600</td>
<td>??</td>
<td>2010 – 1:170</td>
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<td>2007 – 1:74</td>
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<tr>
<td>2008</td>
<td>905,500</td>
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<tr>
<td>2007</td>
<td>1,355,000</td>
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</table>

100 million+ Homes Available for Energy Upgrades
Retrofits Increased in 2010

- Homeowners are thinking more long term
  - Want to lower operations cost
- Energy Efficiency / “Green” Movement
  - Save Money
  - Tax Incentives

Increased Retro activity ➔ Increase homeowner complaints
WHY???
The House is a System

• The house or building is a “System” so changing any single material or function can affect other parts of the building.
• Have a reason for every change you make and consider the benefits and the consequences.
Several Dynamics Occurring

- Wind Loads
- Stack Effect
- HVAC Operation
- Interior Convection
- Interstitial Convection
- Appliance and Flue Draft
The House is a System

- Anything we change will change the way the system works.
- For instance, if we seal the attic we stop attic Exfiltration which then stops most of the Infiltration.
What applications are most common?

- Attics
  - Closed Attics
  - Attic Floors
- Crawlspaces
  - Closed Crawlspaces
  - Subfloors
- Basements
- Rim Joists
- Wall Injection
What do these applications have in common?

- Significantly changes the thermal envelope
  - Lowers natural air changes
  - Lowers heat and moisture loads
  - Improves energy performance
- Lower operations cost
- Energy savings is #1 reason for upgrade

$\text{$$$}$
Prioritize the Retrofit

• Start at the top
  ▫ Reduce losses to Stack Effect by sealing the attic
  ▫ Reducing Exfiltration equally reduces Infiltration

• Go to the Bottom
  ▫ Seal the Crawlspace or Basement

• Seal the Rim Joist
• Seal Outlets, Doors and Windows
Start at the top – The Attic

- Reduce losses to Stack Effect by sealing the attic
- Reducing Exfiltration equally reduces Infiltration
• Winter Stack Effect
  ▫ As air warms inside the house it rises and creates pressure against the ceiling
  ▫ Cracks and gaps in the ceiling and roof assembly allow Exfiltration
  ▫ An equal amount of Infiltration enters through cracks and gaps in the lower half of the house.
• Summer Stack Effect
  ▫ Hot air Infiltrates through cracks and gaps in the ceiling and upper half of the house
  ▫ The A/C system cools air which makes it very dense and very heavy
  ▫ The heavy, dense air sinks to the floor and Exfiltrates through cracks and gaps

Compliments of Fine Homebuilding Magazine
Commercial Buildings

- The taller the building the greater the stack effect
Commercial Buildings

- Stack Effect can be so great that out-swing doors are difficult to open.
- Stack Effect is the reason we have revolving doors.
Reducing Exfiltration Reduces the Coincident Infiltration
Unvented vs. Vented Attic

**Pros**

- Ductwork in attic is inside the thermal and pressure boundary
- Wiring and other utilities on the floor of the attic are accessible
- Sometimes easier to walk around the attic

**Cons**

- Uses more foam
- Often difficult to fully seal the eaves
- Any odors in the old musty attic are now essentially in the living space
- Any foam VOCs are in your living room
Unvented Attics Can be Done Well
And Work Very Well !!!

R-30 Fiberglass Batts in Cathedral Ceiling

R-20 Low Density Foam Sprayed to Roof Deck
Vented VS Unvented Vaulted Ceilings

- Vented Vaulted Ceilings: Humid indoor air enters the roof and travels to the outside. Humid outdoor air enters the roof and returns to the space.
- Unvented Vaulted Ceilings: Humid air cannot reach the underside of the cold roof sheathing. Humid indoor air is denied entry.
Unvented Attics

Never Install Spray Foam on both the Roof Deck and the Floor of the Attic !!!
Ducts Must Still Be Sealed

- Ducts in unvented attics must still be sealed to prevent the attic air from entering the house.
Unvented Attics can also be Very Problematic

- Often not fully sealed
- Odors from foam
- Odors from old attic
- Odors/off-gassing from house
- Existing attic insulation is difficult and costly to remove
- Ice damming potential increases in heavy snow load areas
- Shingle life is reduced by about 5%
Completely Sealing is Often Difficult

- Existing insulation MUST be removed.
- Eave insulation is sometimes difficult
- Spray foam in the eaves with the gypsum board in place is often difficult
- Medium density (closed-cell) foam is difficult to spray at less than 2 or 3 inches. Greater thicknesses can self-ignite.
The Original Insulation Was Not Removed Before Spraying the Roof Deck
Ice Damming

- Ice damming occurs when the snow insulates the exterior of the roof. The ratio of snow to foam must be calculated in Heavy Snow Climates.
Removing Loose Fill Insulation Adds Cost and Complexity But is Required
The Existing Insulation Was Removed From This House And...
Spraying the Roof Deck Brings Both The Attic and the Foam Into the Indoor Environment

4-ft Snake Skin
Not Sure What Kind of Critter This Was
# VOCs From Foam

LABORATORY ANALYSIS REPORT

6601 Kirkville Road  
East Syracuse, NY 13057  
(315) 432-5227  
FAX: (315) 437-0571  
www.galsonlabs.com

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Lab ID</th>
<th>Air Vol liter</th>
<th>Raw uq</th>
<th>Total uq</th>
<th>Conc mg/m3</th>
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### VOCs From Foam

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<th>CAS #</th>
<th>Compound</th>
<th>Result µg/Tube</th>
<th>Result µg/m³</th>
<th>MRL µg/m³</th>
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**ND** = Compound was analyzed for, but not detected above the laboratory reportable limit.

**MRL** = Method Reporting Limit - The minimum quantity of a target analyte that can be quantitatively determined by the referenced method.

**BC** = Results reported are not blank corrected.

**DE** = Results reported are corrected for desorption efficiency.
## Contaminants in the House

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<th>Environmental Parameter</th>
<th>Medium</th>
<th>Ref.</th>
<th>Unit</th>
<th>Guideline*</th>
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<td>Bacteria</td>
<td>Air</td>
<td>3</td>
<td>CFU/m³</td>
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<td>179</td>
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<td>CFU/m³</td>
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<td>Fungal Elements</td>
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Other Issues Worthy of Attention

- Framing members thermal conductivity
- Recessed lights
- Flues and chimneys
- Chemical compatibility
- Pipes and Wires
Gang Nail Plates and Framing Members Should Be Sprayed to Reduce Thermal Conductivity

NOTE: IN COLD CLIMATES, EMBED TOP CHORD METAL CONNECTOR PLATES IN SPF TO PREVENT WINTER-TIME CONDENSATION

SPRAY POLYURETHANE FOAM TO SPECIFIED THICKNESS

ROOF SHEATHING

TRUSS TOP CHORD OR RAFTER

ROOF PAPER

CEILING / THERMAL BARRIER AS REQUIRED BY CODE

PROTECT SPF SURFACE FROM IGNITION AS REQUIRED BY CODE

NOTE: IN COLD CLIMATES USE CODE-APPROVED VAPOR RETARDER

SPACE BETWEEN FOAM AND GYPSUM BOARD ALLOWED BUT NOT REQUIRED.
Chimneys and Flues Must Be Sealed

- Rock wool and fire-stop foam works well
Recessed Lights

- Non IC rated can lights = 3” separation from foam and all insulation

- One common method for IC RATED fixtures is to wrap them with R-11 batts then spray foam up to the batt. This allows air to move around the fixture.
CPVC Pipe is incredibly fragile and is affected by many oils and organic compounds, but we have proven that Spray Foam does not cause Environmental Stress Cracks in CPVC pipe or fittings.
Even CAT-5 Cable will Damage CPVC

This CPVC Pipe Failed After 2 Years From the Plasticizers in Cat #5 Communication Wire!!! CPVC Pipe is Extremely Fragile.
November 18, 2009

Re: Spray Polyurethane Foam (SPF) products compatibility with CPVC piping

The use of spray polyurethane foam (SPF) sealants and insulation in walls and ceiling spaces, and chlorinated poly(vinyl chloride) (CPVC) piping for domestic water and fire suppression systems, is becoming much more prevalent within the building construction industry. This has led to some concern that the SPF products may have an adverse effect on the CPVC piping and cause premature failure of the piping system. One such effect is known as environmental stress cracking or ESC. ESC may occur when the CPVC piping is exposed to an incompatible substance while under stress. ESC can result in cracking and failure of the piping at pressures much lower than the rated pressure.

Spray Polyurethane Foam Alliance (SPFA) members, working with a major supplier of CPVC materials, commissioned a study last year to investigate the potential for ESC.

The results of the study show that all of the SPF products tested, including open-cell SPF, closed-cell SPF, one-component foams, and foams made from natural-oil based materials do not cause ESC and are compatible in direct contact with CPVC piping systems.
Compatibility With Romex Wiring

TECHNICAL SERVICES DEPARTMENT

BULLETIN

No. 95
October 2006
(Revised 8/23/07)

Thermal Effects of Type NM-B Cable Installed in a Residence
Encased in Spray-Foam Insulation
In summary:

The National Electrical Code® does not prohibit installing Type NM-B cable in spray foam insulation.

The NEC® contains requirements for derating the conductors when bundled together. These, and all other Code requirements, must be followed.

The manufacturers of Type NM-B cable allow encasing the cable in foam insulation.

The University of Toronto study indicates that the conductors will not be subjected to objectionable temperatures even under very severe conditions.

Type NM-B cable is routinely installed within heavily insulated walls, ceilings, and floors with no reported detrimental effects.
• Foams are approved for use on Uponor (Wirsbo) PEX pipe and fittings

To:
Mr. Rich Houle
Project/Code Development Engineer
Uponor Housing Solutions
Apple Valley, MN 55124

Date: February 29, 2008
Subject: Demilec Spray Insulation Foam

Dear Mr. Houle

Per the test results summarized by Mr. Looney of Solvay Advanced Polymers, I do not envision any problem of Uponor fittings under normal usage due to the application of Demilec polyurethane spray insulation foam.

Therefore, Demilec Polyurethane Spray Foam Insulation is approved for use with Uponor Wirsbo AquaPEX tubing and brass and EP fittings.

With Best Regards
Chandan K. Saha, PhD
Material Scientist
Engineering Product & Systems Development Manager
Retrofits are more complex than new construction

- Define/Create a New Thermal Envelope
- Personnel Restrictions
- Job-site Preparation
- Confined Spaces
- Existing HVAC System
- SPF & Storage
CREATE CLOSED ROOM AROUND HVAC.

PLYWOOD DECK OVER FOAM

EXHAUST AIR

FRESH AIR INTAKE

SEE IMC CHAPTER 7 FOR COMBUSTION AIR REQUIREMENTS

OPEN COMBUSTION APPLIANCE

SECTION OF THE HOUSE WITH MECHANICAL ROOM IN ATTIC.
PLAN - VIEW OF MECHANICAL ROOM.

LOCATION OF HATCHES SERVICE T.B.D. IN FIELD

OPEN COMBUSTION APPLIANCE

VERIFY MINIMUM CLEARANCE WITH LOCAL APPLICABLE CODE
Sealing and Insulating the Attic Floor

- Equally well sealed
- Less foam
- Add additional Rs using inexpensive loose-fill
Hybrid Insulation in Attics

- Low Density or Medium Density Spray Foam
- Loose Fill Insulation added to Prescriptive R-Value

Adequate Attic Ventilation Must Be Maintained
Ducts Are Well Sealed and Insulated With Spray Foam

- Be careful with open cell in hot humid climates
- Spraying most flex duct voids the UL listing of the vinyl jacket
Once the Attic is Sealed, Go to the Basement or Crawlspace

- Most air that exits the attic comes from the crawlspace
- Sealing the underside of the floor is relatively easy in many cases
- Always use closed-cell foam on concrete below grade
Spraying the underside of the floor
Ductwork Can be Sealed With Foam
Avoid Spraying Directly on Flex Duct
Unvented Crawlspace
Crawlspace Rim Joists

Be careful with frost resistant hose bibs.

Foam expands to fill all gaps, holes, and joints susceptible to wood movement.

Spray foam sticks to the rim joist, eliminating the condensing surface.
Pour Foam for the Rim Joist

• Rim Joists are the leakiest part of any building
• Retrofitting foam can be fairly easy
Air Leakage From the Crawlspace to the Attic

- Drain, Waste and Vent Pipes create air leakage pathways through the interior walls.
• Air currents follow Drain, Waste and Vent Pipes through the interior walls from the crawlspace to the attic
• Sealing both attic and crawl stops air leakage
Personnel Restrictions

- Occupants cannot be present during application
- Re-occupancy is allowed 24 hours after SPF application
Job site preparation

- Existing insulation must be removed
- Protect valuables inside building
  - Overspray
  - Direct contact damage
- Building HVAC must be off during application
Confined Spaces

- Cross Ventilation
  - During spray operation
  - For 24 hours after spraying
  - Overspray in exhaust air
- Personal Protection Equipment
OSHA recommends both supply and exhaust fans for balanced ventilation while spraying polyurethane foams.
Existing HVAC System

• Open vs. sealed combustion appliances
• Mechanical closet
• HVAC sizing???
• Mechanical ventilation
• CO detector
Be Aware of This Section!!!

SECTION R315
CARBON MONOXIDE ALARMS

R315.1 Carbon monoxide alarms. For new construction, an approved carbon monoxide alarm shall be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms in dwelling units within which fuel-fired appliances are installed and in dwelling units that have attached garages.

R315.2 Where required in existing dwellings. Where work requiring a permit occurs in existing dwellings that have attached garages or in existing dwellings within which fuel-fired appliances exist, carbon monoxide alarms shall be provided in accordance with Section R315.1.

R315.3 Alarm requirements. Single station carbon monoxide alarms shall be listed as complying with UL 2034 and shall be installed in accordance with this code and the manufacturer’s installation instructions.
SPF & Storage

- Limited to service of utilities
- Thermal barrier is required to allow storage
- Typical methods to allow storage
  - ½” gypsum or E119 approved material
  - Rockwool/mineral fiber
  - Spray applied cement
  - Tested intumescent paint
Recommendations

- Sealed spaces must be completely sealed
- Occupants should vacate for minimum of 24 hours
- Vent confined spaces during application and for 24 hours until occupancy
- Insulate attic floor
  - Often easier than roof deck
  - Minimize complaints
Prioritize the Retrofit

SEAL IT TIGHT AND???
Prioritize the Retrofit

SEAL IT TIGHT AND VENTILATE RIGHT!
Tighter envelope will amplify problems

- Off-Gassing of Building Products
- Vents
- Filthy Areas
- Major Water Events
- Applicator Error
Defining/Creating the thermal envelope

- Seal existing ductwork
- SPF must be applied to top plate
- Create dividing/separation walls to garage
New Construction as a “Retrofit”

- Material change
  (Should have gone through plans review)
- Building was not designed for SPF
  - HVAC sizing
  - Combustion appliances
  - Air changes
The House is a System

- The HVAC system must be balanced with a slightly positive pressure in the living area.
- When outside air is introduced to the return side of the furnace or air handler the house will have the required proper positive pressure if all ductwork is inside the conditioned envelope.
Retrofit Unvented Attics

• In order to reduce the potential for foam or other attic odors to enter the house, the attic should be slightly negatively pressurized to the house. A small fan ducted to the outside usually solves the problem if all of the HVAC ducts are sealed.
Ducts Must Be Sealed

- Ducts in unvented attics must still be sealed to prevent the attic air from entering the house.
The House is a System

- If the ducts are not inside the conditioned envelope and they leak, the house pressure cannot be balanced.
- Leaking supply ducts in the vented attic causes the house to suck.
Proper Ventilation is Required

- When we tighten a house by spraying foam we must also supply a ventilation system.
- HRV’s and ERV’s are examples of high performance ventilation systems.

Build it Tight and Ventilate Right
Closed Cell Foam Has Special Issues

- 2” Maximum thickness per pass
Weatherization and Retrofits

Retrofits in 2011 and Beyond