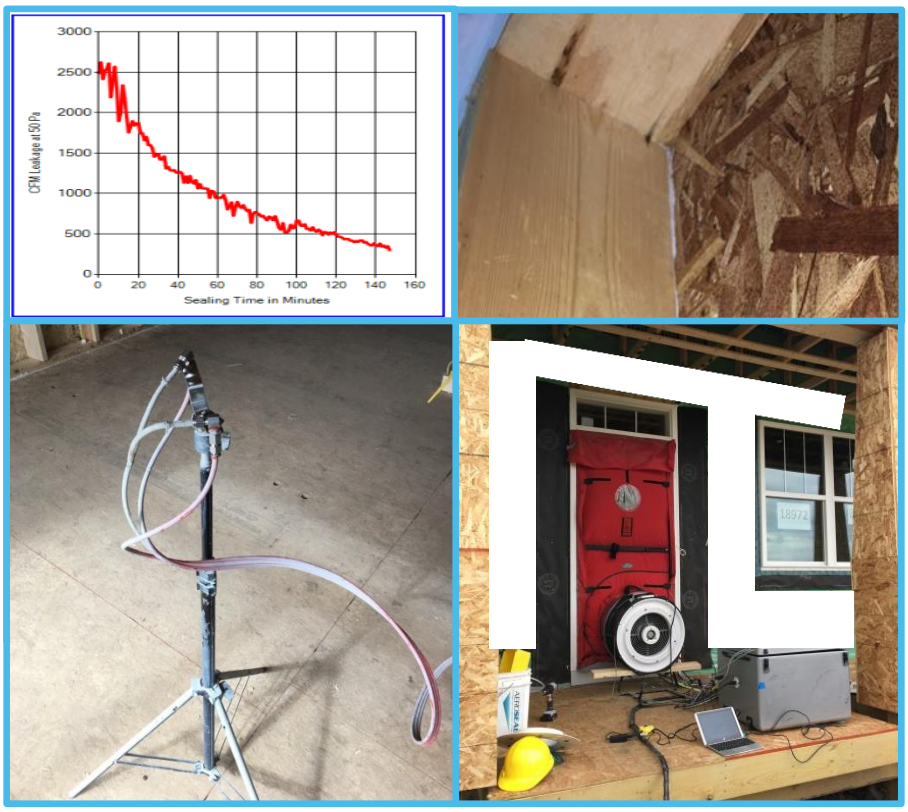
Initial House Assessments & Sealing Options:



July 2017

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Contents

Summary

Visual assessments of houses under construction for this builder showed an overall high quality of air sealing. This was confirmed by HERS rater reports which showed an average tightness of 1.31 ACH50 which is 56% below the Minnesota code requirement of 3.0 ACH50. While there is some opportunity for the AeroBarrier method to produce tighter houses, the greatest benefit would be a possible reduction in overall sealing costs by eliminating many of the current sealing practices. The house inspections and experience with the AeroBarrier method suggest that over half of the envelope air barrier details could be sealed by the AeroBarrier method.

The AeroBarrier demonstration of the house located in Lakeville Minnesota was very successful. The exterior enclosure of the house was largely complete, but the insulation, drywall, and rim joist spray foam had not been installed. The initial house leakage was approximately 2,200 cfm50 and after 2.5 hours of sealing that was reduced by 84% to 358 cfm50 or 0.64 ACH50. This is 79% below the State of Minnesota code requirement of 3.0 ACH50. It is also 51% less than the average house tightness of 1.3 ACH50 for the four completed HERS rated houses. This very tight construction was achieved without the poly vapor/air barrier in place on the walls and without the spray foam insulation/air sealing of the rim joists. This suggests that the current level of house tightness could be produced without much of the current air sealing when AeroBarrier sealing is applied. The next step is to schedule a meeting with the Building America project team (Ed VonThoma and Dave Bohac) to discuss the initial findings and plan for the AeroBarrier sealing of 5 – 6 houses.

Air Sealing Assessment

On-site visual inspections were used to qualitatively assess the envelope air barrier of recently completed houses. A checklist of common leakage sites was used to guide the inspection process and provide structure to the results. The visual inspection checklist is based on the Air Leakage section of the EPA ENERGY STAR Rater Field Checklist. The 26 components are divided into seven categories. The inspections provide information about the quality of sealing work (excellent, acceptable, poor, no attempt), who performed the sealing, what material was used, and the potential for AeroBarrier sealing to replace current methods.

Ed VonThoma conducted field inspections of two houses in the Lakeville subdivision on May 16 and May 18. One of the houses was at the rough-in stage of construction and the other was at the pre-drywall stage. The results from those inspections and experience from other houses constructed by this builder was used to generate Table 1 shown below and photos of a sample of the sealing details are shown in the photos in Figure 1. The inspections showed an overall high quality of air sealing. The level of quality for all except three components was either excellent (18) or not applicable (5). Only the sealing of the attic access panel was considered to be poor[1]. This qualitative assessment is consistent with the air leakage test results from the four HERS rater reports. The average tightness of those four houses was 1.31 ACH50 or 56% below the State of Minnesota code requirement of 3.0 ACH50.

The inspections were also used to identify house components that possibly could be sealed by the AeroBarrier process instead of current methods. Table 1 indicates that half of the components could be sealed by the AeroBarrier method[2]. In summary, the initial assessments indicate that the tightness of the houses is already consistently below code with some opportunity for leakage reduction. However, it appears that the greatest benefit for the AeroBarrier method would be a possible reduction in overall sealing costs by eliminating many of

[1] Sealing is accomplished by the texture coat being applied to the ceiling. If someone were to use the access panel that sealing will be broken. The code requires the attic hatch to be weatherstripped.

[2] An evaluation of fire code requirements and feedback from code officials is necessary to confirm sealing items that could be replaced with aerosol sealing.

the current sealing practices. A later section of this report (*AeroBarrier Air Sealing Opportunities*) provides additional information on opportunities to eliminate current sealing practices.

Category	Component	Who does sealing?	Material used for sealing?	Can AeroBarrier Replace?	Quality of Seal Work
Ceiling/Attic	Attic access panels	Drywall Contractor	Ceiling texture coat	No	Poor
	Drop down stairs	N/A			N/A
	Whole-house fans	N/A			N/A
	Recessed lighting fixtures	Insulation Contractor/Electrician	Polyethylene sheet/Gasketed fixture	Yes	Excellent
	Drop ceiling/soffit	N/A			N/A
Walls	Exterior Walls	Insulation Contractor	Polyethylene sheet		Excellent
	Sill Plate	Carpentry Contractor	Sill seal/Caulk	Yes	Acceptable
	Top Plate	Insulation Contracor	Polyethylene sheet/Caulk	Yes	Acceptable
	Drywall to top plate	N/A			N/A
	wall	Carpentry Contractor	Polyethylene sheet/Caulk	Yes	Excellent
	Knee walls	N/A			N/A
Windows, skylights and do	Rough openings	Insulation Contractor	Can Foam	Yes	Excellent
Rim joists		Insulation Contractor	Closed Cell Spray Foam	Yes	Excellent
Shafts, penetrations to unconditioned spaces	Ducts	Insulation Contractor	Can Foam	No	Excellent
	Flues	Insulation Contractor	Can Foam	No	Excellent
	Shafts	Insulation Contractor	Can Foam	No	Excellent
	Plumbing	Insulation Contractor	Can Foam	Yes	Excellent
	Piping	Insulation Contractor	Can Foam	Yes	Excellent
	Wiring	Insulation Contractor	Can Foam	Yes	Excellent
	Exhaust fans	Insulation Contractor	Can Foam	No	Excellent
	Other				
Garage separation walls	Floor cavities aligned with garage separation walls	Carpentry Contractor/Insulation Contractor	OSB/Closed Cell Spray Foam	No	Excellent
Other	Shower/tub on exterior wall	Carpentry Contractor	OSB/Polyethylene sheet	Yes	Excellent
	Stair stringer on exterior wall	Carpentry Contractor	Polyethylene sheet	Yes	Excellent
	Fireplace on exterior wall	Carpemtry Contractor	OSB/Polyethylene sheet	No	Excellent
	Electrial/low voltage boxes on exterior walls	Insulation Contractor/Electrician	Polyethylene sheet/Caulk/Gasketed boxes	Yes	Excellent
	HVAC register boots that penetrate building thermal	Insulation Contractor	Can Foam	Yes	Excellent

Table 1. Assessment of air sealing details based on visual inspections of recent construction

Duct and electric penetration thru exterior wall base plate

Air-tight electric box at exterior wall; caulk base plate/floor joint

Plumbing penetration and caulk gap between studs

Figure 1. Air sealing details

HERS Rater Reports

The HERS rater reports indicated consistently tight houses with quality air sealing practices. We reviewed HERS rater reports on four houses to evaluate the typical air leakage achieved and any common air leakage issues for recently completed houses. The HERS rater reports indicated consistently tight houses with quality air sealing practices. The reports were conducted for houses with a floor area of 3,647 square feet located in Cottage Grove, Minnesota (3 houses) and Lakeville, Minnesota (1 house). The inspections were conducted from August 17, 2016, to March 7, 2017. As shown in Figure 2 below, the air leakage test results ranged from 1.19 to 1.47 ACH50, which is 51% to 60% below the State of Minnesota code requirement of 3.0 ACH50.

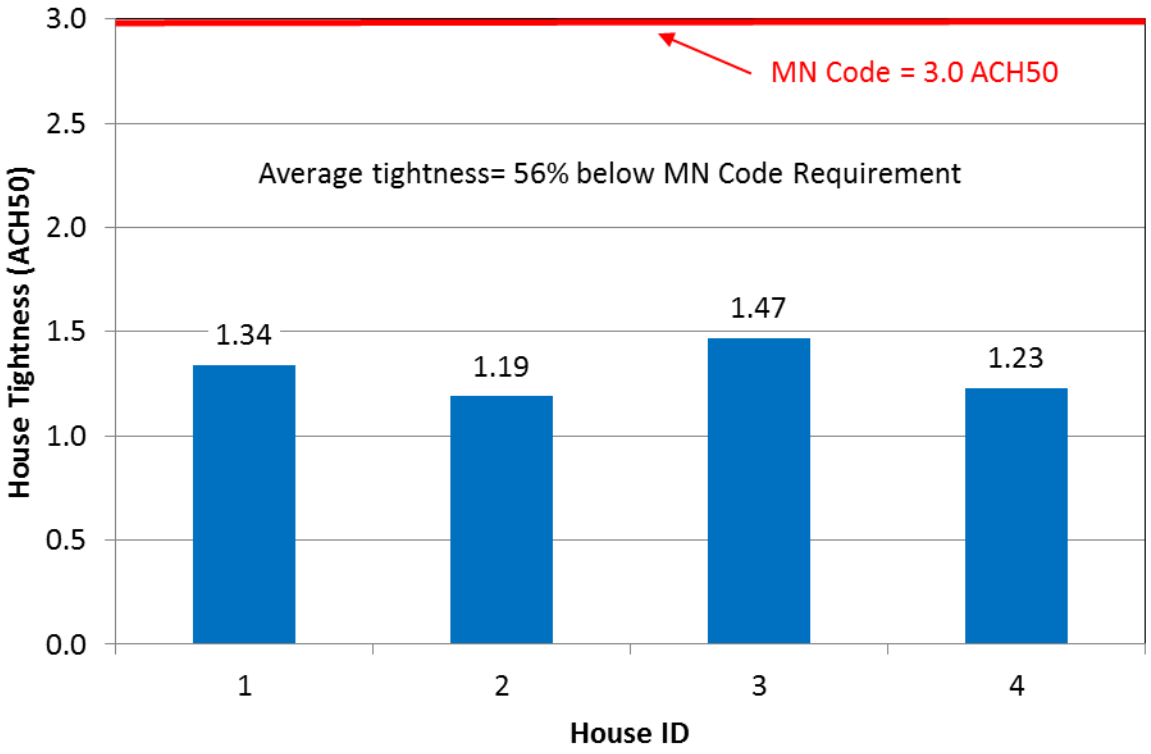


Figure 2. House tightness test results from four HERS rater reports

The reports included notes regarding possible issues and good building practices. Bottom plate leakage was noted as an issue for at least one location for three of the four houses. Other possible issues included:

- Fan housing leakage
- Owners closet bedroom closet ceiling cold spots
- Attic access should be sealed
- Sump pit unsealed
- Ceiling electrical box leakage
- Front of game room, leakage into cavity wall
- Garage service door trim leakage

The reports also noted the following good building practices:

- Sealed bottom plate
- Door threshold sealed
- Ceiling box sealed
- Sealed can light

AeroBarrier Sealing Demonstration

A demonstration of the AeroBarrier sealing process was completed by Aeroseal staff on May 30, 2017, for a house located in Lakeville, Minnesota. Building America project team members Dave Bohac, Ben Schoenbauer, and Ed VonThoma were present along with builder representatives. The AeroBarrier sealing equipment is shown in Figure 3 below. The exterior enclosure of the house was largely complete. The insulation, drywall, and rim joist spray foam had not been installed. Electrical and duct penetrations between floors and at exterior walls were sealed. In addition, foam had been sprayed in the gaps around almost all of the windows. Reinforced poly sheets were installed on second floor ceiling in order to complete house air barrier and allow pressurization for the aerosol sealing to be performed. Photos of some of the sealing preparations and manual sealing are shown in Figure 4.

The following items were temporarily sealed:

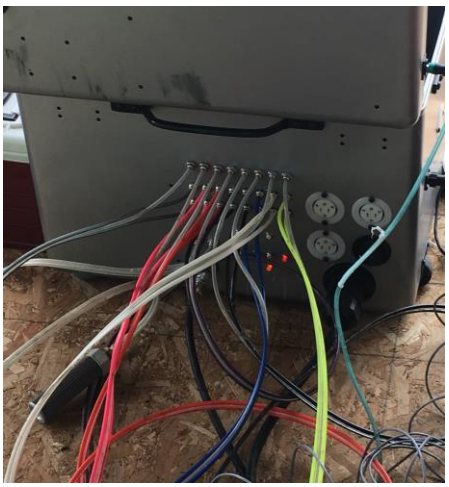
- Bathroom exhaust fan inlet
- Kitchen exhaust fan duct
- ERV inlet and exhaust ducts
- 1" holes in 2nd floor flooring above garage
- Furnace combustion air and vent
- Water heater vent
- Sealed combustion gas fireplace inlet/vent
- Dryer vent

Spray foam was used to seal multiple gaps between the first floor living space and garage prior to the AeroBarrier sealing. These included large (> 3/8”) gaps around electrical penetrations, duct penetrations, and near ceiling joists.

The AeroBarrier sealing was very successful. The sealing was conducted for approximately 2.5 hours (see AeroBarrier sealing report in Figure 6 below). There was not an accurate measurement of the house leakage prior to the AeroBarrier sealing. The leakage at the start of the sealing was approximately 2,500 cfm50. However, some manual sealing of the leaks between the garage and living area were sealed during the first 10 to 15 minutes of the AeroBarrier sealing. If it is assumed that 300 cfm50 sealing was due to the manual sealing, the “initial” house leakage for the AeroBarrier sealing would have been approximately 2,200 cfm50. The sealing was paused after 90 minutes and the leakage was 662 cfm50 at that time. The sealing continued for another 60 minutes. Photos of aerosols seals are shown in Figure 5.

A multi-point house leakage measurement at the end of the AeroBarrier sealing resulted in a tightness of 358 cfm50 or 0.64 ACH50 (see Figure 7). The reduction of 84% is consistent with the reductions obtained for previous projects. This is 79% below the State of Minnesota code requirement of 3.0 ACH50. It is also 51% less than the average house tightness of 1.31 ACH50 for the four completed HERS rated houses and only 7% higher than the Passivhaus standard of 0.6 ACH50. This very tight construction was achieved without the poly vapor/air barrier in place on the walls and without the spray foam insulation/air sealing of the rim joists. This suggests that the current level of house tightness of 1.3 ACH50 could be produced without much of the current air sealing when AeroBarrier sealing is applied.

Pressurization fan installed in front entry



Sealant and compressed air lines

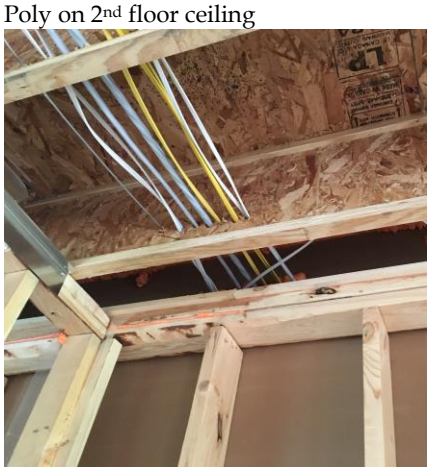
Spray nozzle

Figure 3. AeroBarrier sealing equipment

Poly on 2nd floor ceiling

Temporary cover of shower base

Temporary seal of bath fan inlet

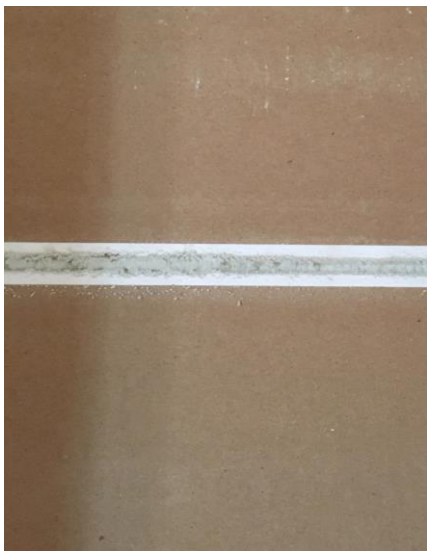


Foam seal electrical penetrations to garage

Foam seal gap at top of garage drywall

Tape used to temporarily seal 1″ holes in flooring

Figure 4. Example of preparation for AeroBarrier sealing



Gap between drywall sheets

Gap between framing and sheathing

Rim joist gaps

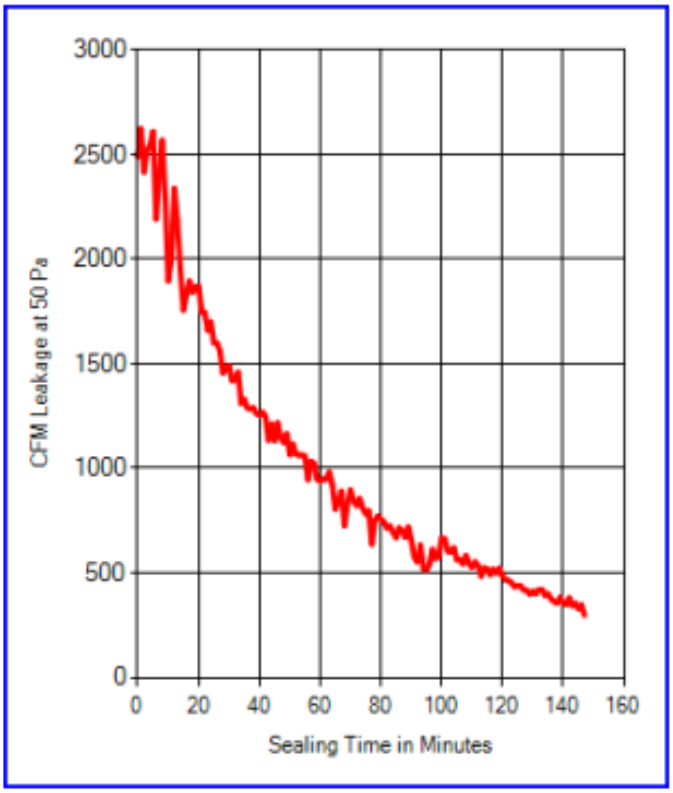
Figure 5. Example aerosol seals

AEROBARRIER™
Breakthrough Envelope Sealing Technology By Aeroseal

Certificate of Completion

Envelope Sealing Performed For:

Lakeville, MN 55044



Overall Sealing Results

When we arrived,

YOUR HOME HAD:

2507.9 CFM of Leakage, equivalent to a

312.6 Square Inch Hole or **5.4 Air Changes per Hour**

*(for your **3500** square-foot structure enclosing an approximate volume of **28000** cubic feet).*

After we finished,

YOUR HOME HAS:

297.8 CFM of Leakage, equivalent to a

37.1 Square Inch Hole or **0.6 Air Changes per Hour**

This corresponds to a 88.1% Reduction in Envelope Leakage.

Note: Envelope leakage and air-change results are calculated at a standard pressure of 50 Pa.

Aeroseal Technician

Aeroseal Case ID **9928**

Date of Seal **5/30/2017**

System Description **Home Envelope**

Seal Description **Envelope Sealing**

Hardware **EnvelopeSeal**

AEROSEAL®
Duct Sealing From The Inside

Envelope Sealing Performed By:

Aeroseal LLC
7989 S Suburban Rd
Centerville, OH 45458
Phone: 937.428.9300

Figure 6. AeroBarrier sealing report

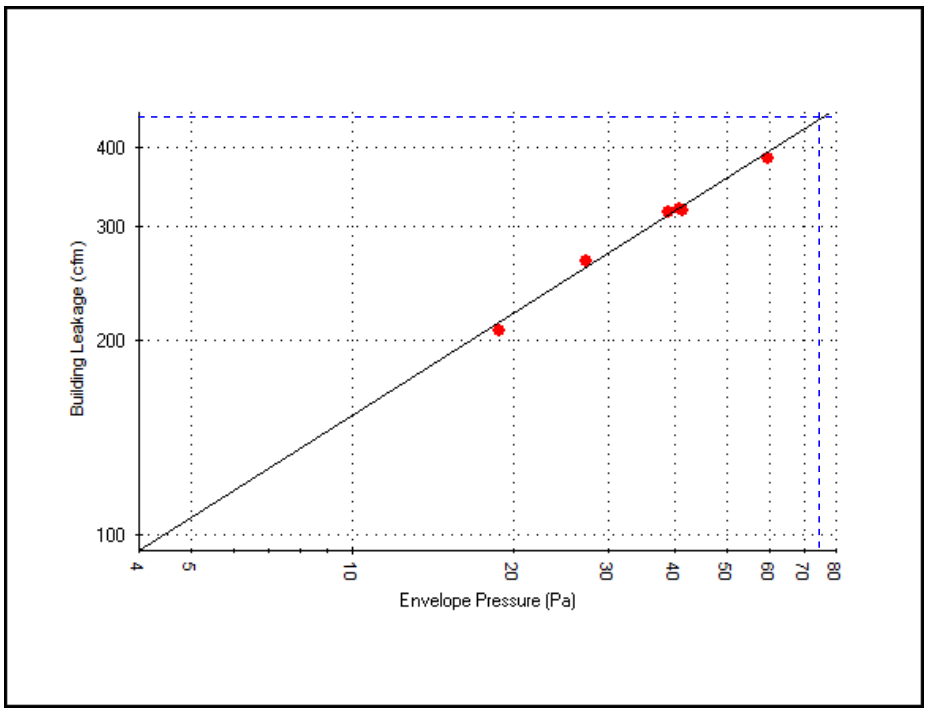


Figure 7. Post-sealing house leakage measurements

Envelope Air Sealing Options

The goal of this project is to determine the best stage(s) of construction to apply AeroBarrier sealing and any current sealing methods that can be eliminated when AeroBarrier is used. The objective is to reduce construction costs, improve house tightness, and seamlessly integrate AeroBarrier sealing into the construction process. The research project tasks have been designed to provide a step-wise, iterative procedure so that experience from initial houses is used to improve the approach for later houses. Results from the initial house assessments and demonstration of AeroBarrier sealing will be used to identify the first two sealing approaches that will be used for five to six of the builder's houses.

As part of the house component leakage assessment, we evaluated which current sealing methods could likely be eliminated with the application of AeroBarrier sealing. This was based on an understanding of how each building component is currently sealed, whether the component air leaks would be accessible during the AeroBarrier process, and whether the leakage gaps would be small enough to be sealed by the AeroBarrier process. Table 2 below lists the 13 components that were judged to have current sealing methods that might be eliminated by AeroBarrier sealing.

This is a list of current sealing to consider for elimination for the first two approaches for this project. Other factors (e.g. likely cost savings, level of confidence in AeroBarrier sealing to achieve similar or improved tightness, impact on construction process) should also be evaluated. The meeting with project staff and builder representatives will discuss all these factors and agree on a stage of construction and sealing eliminated for the next sets of houses.

Component	Category	Material used for sealing?	Quality of Seal Work
Carpentry Contractor			
Shower/tub on exterior wall	Other	OSB/Polyethylene sheet	Excellent
Stair stringer on exterior wall	Other	Polyethylene sheet	Excellent
Interior partition wall to exterior wall	Walls	Polyethylene sheet/Caulk	Excellent
Sill Plate	Walls	Sill seal/Caulk	Acceptable
Insulation Contractor			
Top Plate	Walls	Polyethylene sheet/Caulk	Acceptable
Rough openings	Windows, skylights and doors	Can Foam	Excellent
Plumbing penetrations	Shafts & penetrations to unconditioned spaces	Can Foam	Excellent
Piping penetrations	Shafts & penetrations to unconditioned spaces	Can Foam	Excellent
Wiring penetrations	Shafts & penetrations to unconditioned spaces	Can Foam	Excellent
HVAC register boots that penetrate building thermal envelope	Other	Can Foam	Excellent
Rim joists	Rim joists	Closed Cell Spray Foam	Excellent
Insulation Contractor/Electrician			
Electrial/low voltage boxes on exterior walls	Other	Polyethylene sheet/Caulk/Gasketed boxes	Excellent
Recessed lighting fixtures	Ceiling/Attic	Polyethylene sheet/Gasketed fixture	Excellent

Table 2. Current air sealing that could possibly be eliminated with AeroBarrier sealing

Remaining Work Scope and Proposed Timeline

The next step is to schedule a meeting with the Building America project team (Ed VonThoma and Dave Bohac) to discuss the initial findings and plan for the AeroBarrier sealing of 5 – 6 houses. Table 3 below lists the remaining project activities and proposed timeline.

Activity	Time Required (hrs/house)	When Occurs
Meet with Building America project team to identify two different options for applying aerosol sealing (stage of construction and sealing eliminated). Set tentative schedule for assessments and sealing of 5-6 houses and assessments of 2 non-sealed houses.	2 - 3	July 2017
Leakage assessment/test and aerosol sealing of 5-6 houses. Pre-sealing assessment/test[3] Aerosol sealing and post-sealing assessment/test Construction complete assessment/test	 1.5 – 3 3 – 6 1– 2	August 2017 – October 2017
Leakage assessment and test of 2 non-aerosol sealed houses. Similar stage of construction as aerosol sealing Construction complete	 1.5 – 3 1 - 2	August 2017 – October 2017
Meet with project team to review results from first 5 – 6 houses and develop sealing plan for 2 additional houses.	1 - 2	November 2017
Leakage assessment/test and aerosol sealing of 2 houses. Pre-sealing assessment/test Aerosol sealing and post-sealing assessment/test Construction complete assessment/test	 1.5 – 3 3 - 6 1– 2	December 2017 – February 2018
Leakage assessment and test of 2 non-aerosol sealed houses. Similar stage of construction as aerosol sealing Construction complete	 1.5 – 3 1 - 2	December 2017 – February 2018
Meet with project staff to review results for 2 houses and identify best sealing approach or approaches.	2 – 3	March 2018

Table 3. Project activities and timeline

[3] Best to perform pre-sealing visit one or two days prior to AeroBarrier sealing.