BPI ANALYST–ENVELOPE AUDIT FIELD EXAM CHECKLIST

1. Pre-Inspection – Homeowner Interview *(3 minutes)*
   - A. Turn on & zero CO Meters. **Determine ambient CO:**
   - B. **Record Outside Temperature:**
   - C. Homeowner interview:
     - 1. **Any comfort issues and complaints,**
     - 2. What are their objectives, why do they want an audit?
     - 3. **Review last 12 months of utility bills** – determine peak heating and peak cooling consumption
     - 4. **Calculate base load** (from 3 lowest months when no heat or AC is used) – KWH for appliances, home entertainment systems lighting, water heating

2. Exterior inspection *(10 minutes)*
   - A. Any **moisture issues** (drainage plane, ponding, gutters, roof leaks, flashing, condensation, etc.)
   - B. **Structural Issues** (Sagging roof, uneven structure, cracked walls & foundation, rotted wood, etc.)
   - C. **Safety Issues** (Electrical, Asbestos, Mold etc.)
   - D. Locate gas meter/gas lines – **check for leaks w/Leakator** - soap bubbles to confirm
   - E. Look for thermal bypasses high & low (intersecting roof lines, garages, porches, cantilevers)
   - F. Look for envelope penetrations in foundation, walls, roof allowing airflow (stack effect)
   - G. Look for **rooftop exhaust terminations** for bathroom and kitchen fans.
   - H. **Check out type of attic ventilation.** Soffit & Ridge Vents? Gable vents and turbines? Other? Does it appear to be adequate?
   - I. **AC equipment** (heat pump, A/C compressor, etc.) **How many tons?**
   - J. Any possible pressure/air barrier issues (cracks in foundation, leaky windows, door weather stripping, etc.)
   - K. **Types of windows** (single or double pane, wood, metal, condition, etc.);
     **Are there storm windows? Low E coating?**
   - L. **Which direction does the house face?** Windows on south and west side may need shading in warm climates.
   - M. **Inspect Crawlspace** – look for moisture issues; inspect ductwork; if vented, discuss how to enclose/encapsulate the crawlspace and advantages
   - N. **Mention need to sketch exterior dimensions** of the building envelope
3. Interior inspection – while making house ready for diagnostic testing *(20 minutes)*

- A. Identify any **Health and Safety** Issues
- B. Identify **moisture related problems** (staining, mold, rot, moisture). Make recommendations for corrective actions.
- C. Identify **indoor air contaminant** sources (VOC pollutants, asbestos, CO, lead paint). Make recommendations for corrective actions.
- D. Identify **fire and electrical hazards** (flammables, structural paths (chases, balloon framing)). Make recommendations for corrective actions.
- E. **Check condition and fit of windows and doors**, weather stripping and sealing.
- F. **Close fireplace dampers/doors.** If unvented gas fireplace, recommend replacement.
- G. Note the location of supply and return registers
- H. Check for **insulation in exterior walls** (houses before 1965)
- I. Locate all **thermostats**, point out the **supply and return registers**, range hoods, bathroom fans, dryer vents, etc.
  - 1. Mention upgrading to **programmable thermostats**
  - 2. Mention need to verify whether exhaust fans are vented to outdoors
  - 3. **Perform toilet paper test on bathroom and kitchen exhaust fans**
- J. **Document heat loss implications** (poor “R” or “U” values in windows, doors, attic hatches) and savings opportunities.
- K. Identify **lighting types** for upgrade opportunities
- L. Check out **kitchen appliances; age of refrigerator:**_____; Is it Energy Star rated?
- M. **Test Gas Range for CO in the undiluted flue gas** (or tell Proctor how it’s done)
  - 1. Remove any items from the top of the oven/range
  - 2. Make sure self-cleaning features are not activated
  - 3. Open window or turn on exhaust fan
  - 4. **Operate oven for 10 minutes** to reach highest temperature *(steady state)*
  - 5. Check personal CO meter for **AMBIENT** CO about 5 feet from the range:
  - 6. Test for CO at oven sleeve, before dilution air (usually at back of the cooktop)
  - 7. Record ppm: _____; make appropriate recommendations according to below:

<table>
<thead>
<tr>
<th>BPI Recommended Action Levels for Gas Ovens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always recommend that homeowners install a CO detector in kitchens that contain an unvented range top and oven. Encourage the homeowner to turn on the kitchen range fan whenever the oven or range is in use.</td>
</tr>
<tr>
<td><strong>Level I Action – 100 ppm to 300 ppm</strong> You must install a carbon monoxide detector &amp; make recommendation for service</td>
</tr>
</tbody>
</table>
N. **Inspect the attic**
   1. Insulation type, amount, effectiveness; wind washing, **soffit baffles?**
   2. **Estimate the R-Value of the insulation:** ______
   3. Describe where and how to safely seal the attic floor (top plates, plumbing & wiring penetrations, recessed can lights, chases, drop soffits, etc.)
   4. Make sure exhaust fan ducts exit the roof or side wall

O. **Inspect ductwork for proper installation**, leakage and air sealing, and insulation.
   1. R-value of duct insulation: _______. Are ducts & cabinet air sealed?

P. **Identify and locate all Combustion Appliance Zones (CAZ),** utility rooms, living space, attics, garage, crawlspaces

Q. **Inspect the BASEMENT;** point out need to air seal & insulate perimeter rim joist –

R. **Identify space inside and outside of thermal and pressure boundaries.** Both should be aligned and continuous. Make recommendations- note areas to pay attention to during the blower door test

S. If present- **Inspect Crawlspace** – moisture issues, where is insulation; is ductwork sealed & insulated? How can crawlspace be encapsulated?

T. IF NEEDED, mention need to **measure & sketch interior dimensions** of bldg envelope

**Comments:** _______________________________________________________________________________________
____________________________________________________________________________________________________

4. **Square footage/volume from measurements in steps 1 & 2** *(proctor will provide)*
   A. **House floor area:** ______ ft²   _____ Avg. ceiling height: ______ ft
   B. **House volume:** _____________ ft³

5. **Combustion Appliance Zone (CAZ) Inspection and Preparation** *(7 minutes)*
   A. Record type, make/model, age, EF, BTUs & draft type of water heater:
      _______________________________ natural fan-assisted power sealed
   B. Record type, **make/model, age, efficiency, BTUs** & draft type of furnace/boiler:
      _______________________________ natural fan-assisted power sealed

   C. **Inspect condition & slope of the flue– correct slope ¼ inch per foot?**
   D. Look for signs of flame rollout (soot markings); **look for excessive rust**
   E. **Continually monitor CO in CAZ.** Stop work if CO exceeds 35ppm.
   F. **Gas leaks found?** YES or NO (recommended repair before continuing)
   G. Kinks in flexible gas lines? YES or NO
   H. Flex lines dated prior to 1973? Recommend replacement? YES or NO
   I. Look for signs of flame rollout (soot markings); look for excessive rust
   J. For hydronic system, identify supply/return piping; inspect for insulation & leaks
   K. Check water heater **PT Safety valve, drip leg, blanket, temp setting, 6’ pipe insulation**
   L. **Check HVAC filters.** Recommend regular replacement if excessively dirty
6. CAZ Worst Case Depressurization (WCD) Test *(15 minutes)*

☐ A. Turn off all combustion appliances, **switch water heater to pilot**
☐ B. Turn off all ventilation appliances (exhaust fans, range hoods, dryers, etc.)
☐ C. Close all exterior doors/windows and open interior doors
☐ D. **Remove furnace filter** before test if it is excessively dirty

☐ E. Connect hose to **REFERENCE-A port** on the manometer & **run hose to outside**

☐ F. **Record the BASELINE ΔP:** _______ *(Do not use Baseline function)*

☐ G. **Turn on all exhaust fans & record ΔP:** _______

☐ H. **Turn on air handler blower(s)** (fan only)

☐ I. **Disconnect reference hose** to outside; attach short hose to manometer **INPUT A**

☐ J. Start at room farthest from CAZ - **Open/close interior doors** to increase negative pressure on CAZ. *(If it blows in your nose (positive) – keep it closed. If the same – keep closed. If negative – leave open)* Work way back to CAZ

☐ K. Reconnect hose to outside (Reference-A); **Record WCD ΔP:** _______

☐ L. **If ΔP in Step K is more negative or the same as ΔP in Step G, continue to Step M.**
   *(If ΔP in Step K is more than 1 PA less negative than the ΔP in Step G, turn the air handler blower(s) off, and repeat Step J)*

☐ M. **Subtract baseline (f) from Worst-Case (k);** Record Net WCD ΔP: _______

☐ N. **Net WCD must be less negative** (more positive) than CAZ depressurization limit in the **table below.** Did it **PASS** or **FAIL**?

---

**BPI Combustion Appliance Zone (CAZ) Depressurization Limits (PA)**

<table>
<thead>
<tr>
<th>Venting Conditions</th>
<th>Limits (PA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orphan natural draft water heater (including outside chimneys)</td>
<td>-2</td>
</tr>
<tr>
<td>Natural draft boiler or furnace commonly vented with water heater</td>
<td>-3</td>
</tr>
<tr>
<td>Natural draft boiler or furnace with vent damper commonly vented with water heater</td>
<td>-5</td>
</tr>
<tr>
<td>Individual natural draft boiler or furnace</td>
<td>-5</td>
</tr>
<tr>
<td>Mechanically assisted draft boiler or furnace commonly vented with water heater</td>
<td>-5</td>
</tr>
<tr>
<td>Mechanically assisted draft boiler or furnace alone, or fan assisted DHW alone</td>
<td>-15</td>
</tr>
<tr>
<td>Exhaust chimney-top draft inducer (fan at chimney top); high static pressure flame-retention-head oil burner; and sealed combustion appliances</td>
<td>-50</td>
</tr>
</tbody>
</table>
7. **Combustion Appliance Tests** - CAZ remains in Worst Case *(30 minutes)*

A. **Preparation**
   - 1. Drill holes in flue pipes 1'-2' after draft diverter/first elbow & in draft hood as needed
   - 2. Start with lowest BTU appliance

B. **Spillage Testing**
   - 1. Turn Water heater from Pilot to “On.” Record WH temperature setting: ____
   - 2. Leave Keys on top
   - 3. Tell Proctor you will **recommend homeowner set temp to 120 degrees in the future**
   - 4. Turn Dial to highest temperature to fire unit; **QUICKLY look at flame & comment.**
   - 5. Use a *smoke pen and stopwatch*. Turn on appliance, test for spillage using mirror or smoke stick at every point. **Spillage must stop within 60 seconds**
   - 6. Tell Proctor if spillage test fails under WCD, you would test spillage, draft and CO under Normal Conditions

C. **Draft Testing (wait 5 minutes)** for WH to reach Steady-State Temperature
   - 1. **Reset** manometer
   - 2. Attach short hose with metal tip to **INPUT-A port** on the manometer
   - 3. **Insert metal tip in flue hole 1' to 2' from draft diverter**
   - 4. **Record the ΔP:** ______
   - 5. Determine **min draft pressure from chart below using outside temperature**
     
     Draft reading (**must be more negative than # in chart**)  Did it PASS or FAIL? If draft test fails under WCD, retest under natural conditions.

| BPI MINIMUM Acceptable DRAFT TEST Readings at Outdoor Air Temperature Ranges |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Degrees F | <19 | 20s | 30s | 40s | 50s | 60s | 70s | 80s | >90 |
| Pascals (Pa) | -2.5* | -2.25* | -2* | -1.75* | -1.5* | -1.25* | -1* | -0.75* | -0.5* |

D. **CO Testing**
   - 1. Ensure that CO reading is taken at **steady state**, or at 10 minute mark, whichever is first
   - 2. Test for CO using CO Analyzer by inserting probe through drilled hole in the draft diverter all the way down **in the throat** - so you are testing undiluted gases
   - 3. Measure each side of turbulator:
     
     Record: **Left side ppm:** _____ **Right side ppm:** _____
4. Compare highest CO reading results to table below & make recommendations according to the table.

### Combustion Safety Test Action Levels

<table>
<thead>
<tr>
<th>CO Test Result*</th>
<th>Spillage Results</th>
<th>Retrofit Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 25 ppm</td>
<td>And Passes</td>
<td>Proceed with work</td>
</tr>
<tr>
<td>26 – 100 ppm</td>
<td>And Passes</td>
<td>Recommend that the CO problem be fixed</td>
</tr>
<tr>
<td>26 – 100 ppm</td>
<td>Fails at worst case only</td>
<td>Recommend a service call for the appliance and/or repairs to the home to correct the problem</td>
</tr>
<tr>
<td>100 – 400 ppm</td>
<td>Or Fails under natural conditions</td>
<td>Stop Work: Air sealing work may not proceed until the system is serviced and the problem is corrected</td>
</tr>
<tr>
<td>&gt; 400 ppm</td>
<td>And Passes</td>
<td>Stop Work: Air sealing work may not proceed until the system is serviced and the problem is corrected</td>
</tr>
<tr>
<td>&gt; 400 ppm</td>
<td>Fails under any condition</td>
<td>Emergency: Shut off fuel to the appliance and have the homeowner to call for service immediately</td>
</tr>
</tbody>
</table>

#### E. Combustion Testing for Additional appliances

1. Turn Water Heater back to pilot
2. Test draft of each additional appliance independently under Worst Case Depressurization.

   **Additional Equipment**: Circle if applicable: furnace boiler another water heater

   1. Test for spillage (no spillage after 60 seconds): _________ Pass or Fail
   2. Test for draft Pa: _________ Pass or Fail
   3. Test for CO ppm: _________ Pass or Fail

   **Equipment (if there is yet another inside the conditioned or semi-conditioned space)**

   1. Test for spillage (no spillage after 60 seconds): _________ Pass or Fail
   2. Test for draft Pa: _________ Pass or Fail
   3. Test for CO ppm: _________ Pass or Fail

#### F. Test Appliances Sharing a Chimney TOGETHER

1. Fire all commonly vented appliances simultaneously & test for spillage & draft.
2. Switch water heater to pilot; turn of all other combustion alliances

#### 8. CFM50 Blower Door Test

- Measuring airflow, leakage, air changes per hour (20 minutes)

**A. Preparation**

1. Turn off all combustion appliances,
2. **Switch water heater to pilot**
3. Turn off all ventilation appliances (exhaust fans, range hoods, dryers, etc.)
4. **Open interior doors**
5. Close all exterior doors/windows
6. **Turn off all air handler unit fans**
7. Make sure all fires are extinguished, cover/remove ashes
8. Check for possible Indoor Air Quality (IAQ) issues (mold, asbestos, etc.)
9. **Don’t conduct test if fire is not fully extinguished or IAQ issues are present.**
B. **Setup Blower Door**

1. Fit frame to door & place red canvas over frame
2. Insert frame to door, place reference hose 6-7 feet away from fan outside
3. Insert fan into door, hook up power to fan
   a. HOSE to OUTSIDE connects to Channel A – REFERENCE
   b. HOSE to FAN connects to Channel B - INPUT

C. **Set up manometer**

1. Ensure rings are installed in blower door opening before taking BASELINE reading
2. Set mode to PR/FL @ 50.
3. Set Device to the right blower door:_________; Set Range Config to Open.
4. **BASELINE the Manometer WITH FAN COVERED**
   a. (Press BASELINE => START => wait 20 sec => Press ENTER)

D. **Operate Blower Door**

1. **REMOVE ALL RINGS** and make sure manometer is Configured to OPEN
2. Press “Set pressure” 25 enter; look around – check fireplace
3. Press “Set pressure” 50 enter; wait until house is -50 Pa WRT Outside
   *If B Channel displays “Too Low” or “Lo:*
   a. Stop Fan and add a flow ring
   b. Press Config to match the ring and restart the fan

4. **Record Flow in CFM at 50 Pa of pressure;** CFM50: ___________
5. Press EXIT on Manometer to Stop the Fan

9. **Calculate Air Changes Per Hour – Use CFM50 from above (5 minutes)**

   A. **ACH50 = CFM50 x 60 ÷ Volume**

   \[
   \text{ACH50} = \frac{\text{CFM50} \times 60}{\text{Volume}} = \text{Air Changes per Hour @ 50PA}
   \]

   B. **NACH = ACH50 ÷ n-factor** from chart below

   D. **NACH = _______ ÷ _______ = _______ Natural Air Changes per Hour**

---

### Natural Air Changes Table

<table>
<thead>
<tr>
<th>Zone</th>
<th># of stories</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Well-shielded</td>
<td>18.6</td>
<td>16.7</td>
<td>14.9</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>15.5</td>
<td>14.0</td>
<td>12.4</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>Exposed</td>
<td>14.0</td>
<td>12.6</td>
<td>11.2</td>
<td>9.8</td>
</tr>
<tr>
<td>2</td>
<td>Well-shielded</td>
<td>22.2</td>
<td>20.0</td>
<td>17.8</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>18.5</td>
<td>16.7</td>
<td>14.8</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>Exposed</td>
<td>16.7</td>
<td>15.0</td>
<td>13.3</td>
<td>11.7</td>
</tr>
<tr>
<td>3</td>
<td>Well-shielded</td>
<td>25.8</td>
<td>23.2</td>
<td>20.6</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>21.5</td>
<td>19.4</td>
<td>17.2</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>Exposed</td>
<td>19.4</td>
<td>17.4</td>
<td>15.5</td>
<td>13.5</td>
</tr>
<tr>
<td>4</td>
<td>Well-shielded</td>
<td>29.4</td>
<td>26.5</td>
<td>23.5</td>
<td>20.6</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>24.5</td>
<td>22.1</td>
<td>19.6</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>Exposed</td>
<td>22.1</td>
<td>19.8</td>
<td>17.6</td>
<td>15.4</td>
</tr>
</tbody>
</table>
10. **Determine the Building Airflow Standard (BAS)** *(5 minutes)*
This is the amount of ventilation the house should have; Use the House Volume from step 4

☐ A. **Calculate Ventilation Required for Building**
   \[ \text{Airflow (cfm)} = 0.35 \times \frac{\text{Volume}}{60} = \frac{0.35 \times \text{Volume}}{60} = \text{_____ cfm} \]

☐ B. **Calculate Ventilation Required for People**
   \[ \text{Airflow (cfm)} = 15 \times \text{occupants} \] (occupants = bedrooms +1) = \[15 \times \text{_____} = \text{_____ cfm}\]

☐ C. **Pick the higher of the two above.** This is the **BAS Natural:** \[\text{_____ cfm} \]

**Convert the BAS Natural to BAS50**

☐ D. **Minimum CFM50 = BAS Natural** x N-factor *from table above* = \[\text{_____} \times \text{_____} = \text{_____ BAS50}\]

☐ E. **Multiply BAS50 x 0.7 to get 70% of BAS50** \[\text{_____} \times 0.7 = \text{_____ 70% BAS50}\]

☐ F. **Acceptable Range** **BAS50 Range (100% to 70%):** \[\text{_____ CFM50 to _____ CFM50}\]
   - If you air seal the building envelope to a CFM50 less than the BAS50, mechanical ventilation is **RECOMMENDED**
   - If you **air seal the building envelope to a CFM50 less than 70% of the BAS50**, mechanical ventilation is **REQUIRED**

11. **Conduct room by room inspection with blower door running** *(15 minutes)*

   ☐ 1. **Use Fan Speed Controller** to depressurize house to -50PA
   ☐ 2. Disconnect manometer from hoses – leave speed controller to run the blower door
   ☐ 3. Attach short hose to INPUT-A port
   ☐ 4. **Using smoke stick or hand**, identify significant leakage between conditioned space &:
      - a. the attic (including kneewalls)
      - b. the cellar/crawl,
      - c. exterior walls
      - d. attached garage
   ☐ 5. **Using manometer, isolate pressure differentials between zones**
      - a. Conditioned space to garage
      - b. Conditioned space to attic
      - c. Conditioned space to **unfinished basement** or **crawlspace**
   ☐ 6. Recommend air sealing priorities and tell Proctor how you would air seal

12. **Duct Sealing Analysis** *(10 minutes)*

   ☐ 1. While blower door is running, conduct duct leakage location diagnostics (prioritize repairs, state methods)
   ☐ 2. **Use pressure pan at various supply and return registers**
   ☐ 3. **If the ΔP is >3 PA, or if the average of all register is >1 PA, duct sealing opportunities exist** (if duct is outside the conditioned space and accessible)
   ☐ 4. Tell Proctor that the joints, seams and boot collars in the **ducts and plenum should be sealed with mastic** & the **cabinet** should be sealed with **FSK tape** and that **ductwork outside conditioned space should be insulated to at least R-6**
13. Insulation Analysis *(10 minutes)*

- 1. Determine insulation type, amount, & installation effectiveness
- 2. Make soffit baffling recommendations to prevent wind washing, fire protection, thermal & pressure boundary alignment.
- 3. **Show examples of where the air barrier and insulation are not aligned**
- 4. Make specific recommendations for continuous alignment of air & thermal boundary
- 5. Analyze structural considerations & their relationship to insulating and air sealing
- 6. Identify cost-effective opportunities for insulation (specify savings calc., type & install technique)
- 7. **Attic knee walls** and hotwalls should be enclosed on all six sides with an air barrier.
- 8. Floor insulation should be snug against the underside of the floor
- 9. Note areas benefiting from using dense-pack technique or foam
- 10. Indicate areas where baffling may be required for fire protection

14. RECOMMENDATIONS *(15 minutes)*

List specific air sealing recommendations including suggested materials:

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________
______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

List specific insulation recommendations including type of insulation recommended:

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

List specific duct sealing recommendations including suggested materials:

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

List any recommended appliance, HVAC, DWH or lighting upgrades:

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

List any opportunities for alternative fuel (ie: solar hot water for pool)

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

List any recommended safety improvements:

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________
List any recommendations to solve moisture or IAQ problems

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

List any recommendations for improving attic ventilation

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

Tell proctor which recommendations will likely yield the quickest payback:

______________________________________________________________________________________________________________
______________________________________________________________________________________________________________

14. Test-Out - Don’t forget: (5 minutes)
   A. Tell the Proctor that the house will need to have another blower door test if significant air
      sealing, duct sealing or insulation work is performed.
   B. Tell the Proctor that CAZ Testing will also have to be performed after retrofit work is completed

15. Return to Water Heater
   A. Turn control from Pilot back to “ON” - Return Thermostat dial to original setting
   B. Pick up your keys
House Sketch