# Energy and Water Efficiency Project Implementation Verification Checklist

Language contained in this document is intended to serve as a general template and should be copied, pasted and edited for each specific project. Providing clear expectations of what should be installed and how it will be inspected and verified is the key to maximizing the actual performance of the installed upgrades.

The ***Verifier*** is serving as a technical resource to the ***Client***. The Client should be instructed to withhold final payment to the***Contractor*** until all items are confirmed to the Verifier’s satisfaction. The Contractor should be aware of this requirement and of the inspection and verification measures that will be performed as this language should be included in the project Specifications and Scope of Work (SOW).

Aspects of this document may appear to bleed into a form of commissioning (Cx) but the Verifier is not serving in the capacity of an official Cx Agent. The Contractor is responsible for the work meeting code, manufacturer’s specifications, and meeting the requirements of the Project Specifications and the SOW.

The Contractor should sign off that all work has been completed and is ready for the Verifier to inspect before the Verifier visits the site. As an incentive for rewarding good work and a disincentive for sub-standard performance, consideration should be given to penalize a Contractor if the Verifier is required to make additional visits because the work has not met the specifications.

The following statement is recommended for all final project scopes:

“The Verifier is serving as a technical resource to the Client.  Complying with the following checklist in no way relieves the Contractor from following code, laws and regulations, or manufacturers installation instructions, and the Verifier is not liable if the Contractor fails to comply with those criterion.  If there is a discrepancy between code and the following specifications, the Contractor is to notify the Client in writing of the conflict and once approved, the code requirements will supersede the conflicting specification.  The Verifier’s verification activities shall not be used in lieu of Contractor quality assurance and quality control procedures.  The Verifier assumes no liability or responsibility for any economic or physical performance or damage to property, equipment or other materials as a result of the implementation of the following specifications. ”

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### Retrofit spray foam roofline

A properly installed foam coverage at the roofline, although expensive, offers exceptional thermal and comfort performance and provides significant energy savings (especially if ductwork is brought inside the thermal envelope). After average depth has been consistently verified, the foam will likely require an **intumescent** **coating** which provides a fire “thermal” barrier (it may also serve as an ignition barrier). Ideally the verifier should confirm the proper foam application before the coating is applied.

In general, a properly foamed roof retrofit will involve the following:

* Proper removal, vacuuming and **disposal of the old insulation** on the flat ceiling to remove old insulation fibers and rodent scat (critically important for IAQ concerns)
* Proper removal of old and **unused roof penetrations** so that the foam insulation coverage can be more complete (example: old, unused flue pipe that creates an unnecessary roof penetration)
* Visual inspection for signs of **obvious water leaks** that may need to be addressed
* Proper and complete sealing of all **roof vents**, including
  + Eave and soffit vents – these may be backed with blocking material and then foamed against
  + Gable vents – these may be sheathed with felt covered OSB (for aesthetics) and then foamed against from the inside
  + Ridge vents – spray foam should completely cover and block all light
  + Cap (“turtle”) vents – spray foam should completely cover and block all light
  + Powered Attic Vents should be disconnected and removed before sealing
* **Foam R-values** desired are typically R-13 for vertical attic walls (such as gable end walls) and R-19 to R-20 for flat or sloped rooflines
  + For **Open Cell** (~ ½ lb. density, ~R3.7/inch) – the walls should be sprayed to approximately 3.5” and the roofline should be approximately 5.5”
  + For **Closed Cell** (~ 2 lb. density, ~R6.5/inch) – the walls should be sprayed to approximately 2” and the roofline should be approximately 3”
  + At least **five to ten** **depth measurements** should be taken to assess if the coverage depth is adequate
  + Consistent depth coverage is more important than average depth
* The intumescent coating application should be visually checked for consistent coverage
* A quick visual check should be made to ensure that **combustion appliances** in the “attic” space are high efficiency and do not use formerly vented attic air for combustion air
* In situations where the roof is a low sloped assembly, be sure to specify air sealing and insulation at the upper exterior wall section that is typically hidden above the finished dropped ceiling (see ***Reroof with Continuous Insulation above a Low-sloped Roof Deck*** for details and more options on insulating this wall area with alternate materials)
* Clear identification of locations of blocking, air sealing and insulation
* Unused roof penetrations have been removed, sealed and insulated
* Spray foam insulation information
  + Manufacturer rated R-value per inch
  + Minimum depths and anticipated coverage
* All existing ceiling insulation is removed and floor of flat ceiling is vacuumed
* All roof vents have been completely sealed
* All walls insulated to minimum depth
* All rooflines insulated to minimum depth
* Non-combustible (metal) transitions from combustion venting such as chimneys and flue pipes; spray foam should not be in contact with “hot” pipes – minimum 1” separation; any metal separation pieces should be sealed with fire-rated caulk to the flue or hot surface
* Intumescent coating has been installed completely over foam

### Reroof with Continuous Insulation above a Low-sloped Roof Deck

If a low-sloped existing roof has an older membrane, removing and replacing it with additional insulation and a new reflective membrane can typically be a more cost effective approach than adding spray foam from underneath. Ensure that the new roof membrane is properly tied into the existing drainage assemblies and is properly flashed at likely problem areas such as parapet wall intersections.

Often the finished ceiling below the roof deck is a dropped ceiling assembly and the perimeter tiles can easily be removed to provide access to the upper portion of the exterior wall. This exposed upper exterior wall section can be insulated from the inside using an approved fire-rated insulation product. Crucial air sealing must first occur at the junction between the fluted/waffle roof deck and the top of the exterior wall as well as at any penetrations through the exterior wall that are hidden by the acoustical ceiling tiles. In particular, pay attention to leak paths above entryway doors and architectural features such as porte-cocheres.

* Specify a final insulation R-value of at least 20+ that is continuous and not tapered anywhere to less than R-20
  + Poly-isocyanurate is the most common commercial roof insulation and is approximately R-6.5 per inch
  + Extruded Poly-styrene (XPS) is sometime used and is about R-5 per inch
* Specify a high albedo (reflective) roofing membrane that meets ENERGY STAR and ASHRAE 90.1 specs for solar reflectance and thermal emittance or a Solar Reflectance Index (SRI) > 82
* Make sure any older, unused roof penetrations are removed, structurally supported, and sealed and insulated over before applying the new membrane
* Air seal penetrations and roof-wall junctions at the exterior walls that are hidden above the dropped ceiling
* Insulate exterior walls hidden above the dropped ceiling – use code-approved material
  + Foil-covered poly-iso board (such as DOW Thermax, ~R6.5 per inch)
  + Cellulose batt product (such as Nu-wool *EcoCell,* ~R3.6 per inch)
  + Consult ASHRAE 90.1 for minimum R-value guidance for steel-framed or mass walls (table values below are from ASHRAE 90.1-2007) but consider R-5 as a good retrofit minimum

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Non-Residential | | | Residential | | |
|  | Mass Wall | Steel Frame | Wood Frame | Mass Wall | Steel Frame | Wood Frame |
| Climate Zone 2 | 5.7 c.i. | 13 | 13 | 7.6 c.i. | 13+7.5 c.i. | 13 |
| Climate Zone 3 | 7.6 c.i. | 13+3.8 c.i. | 13 | 9.5 c.i. | 13+7.5 c.i. | 13 |
| Climate Zone 4 | 9.5 c.i. | 13+7.5 c.i. | 13 | 11.4 c.i. | 13+7.5 c.i. | 13+3.8 c.i. |

* Unused roof penetrations are removed and insulated over
* Ensure band area is air sealed and insulated (from inside) if applicable
* Ask for documentation that installed R-value and insulation minimum meets spec
* Check that new membrane is properly tied into existing drainage pathways
  + Thicker insulation levels will move finished height of membrane
  + Inspect membrane connection to parapet, etc.
* Ensure that this roof assembly is not vented

### Retrofit Vented Crawlspace into Closed (Conditioned) Crawlspace

Proper air sealing of vents and penetrations and other prep should be completed before any crawlspace wall insulation is installed. Crawlspace wall insulation retrofits can be complex in their scope and are often unique in their requirements for a specific project; therefore, it is suggested that an expert be consulted for guidance (also consult www.crawlspaces.org). Major components for a retrofit conditioned crawlspace include:

* Bulk moisture concerns have been addressed (exterior drainage, plumbing leaks)
  + External grade slopes positively away from foundation
  + French drain “in ground gutter”
  + No existing plumbing leaks
* Visually inspect for signs of active moisture issues – pooling, puddles, mold
* No extensive mold issues that have not been remediated
* Complete ground vapor barrier installed as per minimum code
  + Vapor barrier is class I vapor retarder (e.g., minimum 6 mil poly)
  + Vapor barrier is installed durably (preferably with adhesive and mechanical fastening)
  + Coverage is 100% with minimum 6” overlapping seams and edges run up foundation walls and piers at least 6”
  + There have been some instances of cat-urine odors emanating from certain white (plastic) poly vapor retarders, so consider all options carefully or ask for a warranty from this risk
* No combustion appliances receive combustion air from the crawlspace area
* Band area – air sealed and insulated (preferably with removable insulation product to allow for pest inspection)
* Existing crawlspace vents have been sealed and insulated
* Existing floor insulation removed and floor penetrations air sealed (to prevent pest entryway and for IAQ)
* Provisions made for termite inspections
  + 3” inspection gap at top of foundation wall, below floor joists
  + 3” gap has movable, hinged “plug” of insulation that can be replaced after inspection
  + Band area shall be capable of being inspected
* Wall insulation coverage and type
  + Crawlspace wall R-values shall meet minimum code for continuous insulation (R-5 for Climate Zones 2 and 3, R-10 for Climate Zone 4)
  + Insulation shall be durably installed against the air barrier foundation wall (preferably with adhesive and mechanical fastening)
  + Insulation shall be moisture resilient
* Access door air sealed and insulated to same as wall
* No off-gassing, combustible, or otherwise unsafe items are stored in this location (e.g., lawnmowers)
* Method of conditioning crawlspace
  + Dedicated dehumidifier with condensate drained or pumped to outside or drain line (the generally recommended option; suggest control target of 55-60% RH)
  + Conditioned air supplied from main HVAC system (less desirable, must satisfy other code requirements)
* Moisture monitoring and high RH level alarm system (suggest target control of 55-60% RH with alarm at 65-70% RH)
* Backup drainage / sump pump system (if applicable)
* Flood plain “smart vents” (if applicable)
* Radon testing performed before and after retrofit
* Signage inside entry to crawlspace explains what this is and how this works  
   *“****NOTICE****:* ***This is a sealed, conditioned crawlspace****.*
  + ***Do NOT******store*** *combustible, off-gassing or otherwise hazardous materials   
    or equipment (e.g., lawn mowers) in this location.*
  + *If insulation is moved for* ***pest control inspection****, it must be replaced.*
  + ***Do NOT*** *remove, puncture or* ***damage floor vapor retarder****.*
  + *Keep crawlspace* ***access door closed*** *and sealed”*

### Flat Attic - Air Seal and Insulation Prep

Proper air sealing and insulation prep should be completed and ideally inspected and approved before any loose fill insulation is installed.

* Air sealing should occur at any flat **ceiling penetrations** – including top plate to drywall connection, holes in top plates for wiring and plumbing, HVAC duct boot to drywall, lighting and other electronics, attic access, etc.
* “Hot pipes” such as flues and chimneys shall have air sealing performed with non-combustible materials (e.g., metal or drywall) and be sealed at hot surfaces with fire-rated sealant (intumescent caulk)
* Attic knee walls shall be blocked at intersection with flat ceiling underneath and have additional insulation (R-18 minimum) and a sealed air barrier on the attic side of the kneewall
* Can lights in an insulated ceiling must be air tight, Insulation Contact (IC)-rated and be air sealed to drywall
* Blown insulation **dams** should be installed at attic access and other locations (such as at chimneys, combustion flues and where the porch ceiling meets the insulated ceiling) to prevent loose-fill insulation from falling out or being tapered at the edges.
* Eave vents should have dams and baffles to channel ventilation above the insulation to prevent wind-washing
* Flags or other indicators that show the location of ceiling electrical boxes should be marked
* Attic access should be insulated and air sealed – e.g., zipper tents and insulated cover boxes
* Best Practice:
  + Raised platforms or catwalks (that allow for insulation to be installed beneath them) will ideally be installed to provide future ability to move around attic without disturbing the soon to be installed insulation
  + Attic access should open onto a flat piece of decking to ease user entry
  + This is an opportune time to seal attic ductwork and consider retrofitting a radiant barrier
  + If onsite inspection of these prep items cannot be performed, have the contractor provide photos of items before insulation is installed
* Confirm blocking and air sealing of bypasses and leakage pathways
* Confirm attic dams and eave vent baffles
  + Ensure no powered attic ventilator fans are connected
  + Check if roughly half of roof ventilation is low while rest is high
* Verify insulation dams installed at “hot pipes”, attic access, porch ceilings, etc.
* Verify radiant barrier has been installed (if applicable)
* Confirm insulation (such as batts) has been or will be installed under platforms and catwalks
* Confirm insulation depth markers are installed correctly or create and photograph marks at certain heights to help verify loose-fill depth

### Flat Attic - Insulation Install

Proper air sealing and prep should be completed and (ideally) inspected and approved before any loose fill insulation is installed. DO NOT INSTALL INSULATION UNTIL AIR SEALING & PREP IS COMPLETE!

* Depth rulers should be installed at 1 for every 300 s.f. for loose fill insulation
* An attic card should dictate the attic floor area, number of bags and installed R-value and depth
* Even and consistent insulation coverage to ensure Grade I installation (as per RESNET Appendix A-11-16)
* If batts are installed, they must be in complete contact with the ceiling drywall
* Insulation coverage should not be compromised by penetrations into the flat ceiling such as light fixtures, speakers, etc.
* Verify insulation dams keep insulation back 1-3” from “hot pipes” such as chimneys and metal flues
* Dams prevent tapering of insulation at porch ceilings, etc.
* Dams allow insulation coverage to extend to attic access (which should also be insulated)
* Attic ventilation
  + Confirm attic dams and eave vent baffles at soffits
  + Ensure no powered attic ventilator fans are connected
  + Check if roughly half of roof ventilation is located low while rest is high

### Retrofit a Combustion Appliance Zone (CAZ) into a Combustion Closet

Although the preference would always be to update existing combustion equipment to high efficiency condensing type (such as a 95% AFUE furnace or a 0.93 Energy Factor tankless water heater), there may occasionally be instances where original equipment is too new and may be kept provided a combustion closet can be retrofitted around it.

As an example, if a one-story commercial building with a flat ceiling and vented attic contains a 1-year-old atmospheric gas water heater and the building hot water usage is low, it may not be worth it to upgrade the water heater. However particularly if any envelope enhancements (e.g., air sealing, insulation, window upgrades) are intended, combustion safety must be addressed.

A properly retrofitted combustion closet will create a chamber around the atmospheric combustion appliance that is sealed off (and ideally insulated) from the occupant’s breathing air inside the building. This chamber is provided combustion air that is supplied by code compliant “Hi/Low vents” which allow separate air for the appliance – either directly from the outside or from an unconditioned, vented location such as a vented attic.

* Provisions shall be made to prevent plumbing or condensate from freezing (e.g., pipe insulation)
* Pay particular attention to air sealing details around the walls of the combustion closet as there are frequently electrical, plumbing, ducting or fuel line penetrations
* Ensure that the closet door is not louvered and contains a tight seal at the bottom threshold
* Specify and confirm insulation in the combustion closet walls
* Verify the Hi/Low vents are installed and connect to an appropriate location to provide combustion air
* Ensure that the combustion flue is properly vented to the exterior
* Signage should indicate that,  
   “**This closet is not intended for storage, the door shall remain closed and the Hi/Low vents must not be blocked**”

### Retrofit New Air Conditioning / Heat Pump System

In general, a new air conditioning system will likely be a packaged, split or a mini split system. A variable refrigerant flow (VRF) system may also be encountered. New equipment should be sized via a proper load calculation based on the package of envelope, lighting and internal load improvements. For heat pumps, specify an outdoor lockout thermostat or other controls to prevent electric resistance operation above 40oF.

* Specify that, at equipment change-out, mastic will be applied internally to all accessible joints and collar connections inside the plenum and at all plenum to cabinet connections
* Photograph/record two model numbers (for the indoor coil and outdoor condensing unit; they should be matched) for split systems and the single model number for packaged equipment. These can be used to verify efficiency via [www.ahridirectory.org](http://www.ahridirectory.org)
* Check area around air handling unit (AHU)
  + for proper duct sealing with mastic (particularly at cabinet and indoor coil connections and penetrations)
  + for proper AC condensate drain details – either by pump or floor/gravity drain and ensure a P-trap and “vent stack” clean out access point
  + for filter access (if applicable) that is properly sealed (temporarily) but still allows clearance for regular filter change out
* Turn on system at thermostat and verify seasonally appropriate operation of heating or cooling system (note, do not operate air conditioner in cooling mode if outdoor temperature is < 60oF)
* For heat pumps in heating mode (assuming the outdoor temperature is above 40oF), verify that backup electric heat strips do not energize if indoor thermostat setpoint is raised by 3-5oF
* If possible and applicable (such as for equipment located in attics or above finished areas), override the drain pan safety switch to confirm that the unit will shut off if the float switch is enabled
* For split systems, the refrigerant line insulation that runs outside should be protected from weather and UV degradation – special paint or metal shielding are two options
* Consider a quick check by counting supply and return duct runs and verifying each register is properly connected (hopefully, the audit identified possible return path problems that have been rectified as part of the upgrade)
* A contractor-provided equipment start-up checklist should be used to verify proper operation and performance
* System Manufacturer & Quantity:
  + Condensing unit model number \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Indoor coil (evaporator) model number \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Coil + condensing unit should be matched
* SEER / HSPF ratings meet spec (via [www.ahridirectory.org](http://www.ahridirectory.org))
* Blower type (if integral such as for a heat pump)
  + Constant speed (PSC)
  + Variable speed (ECM)
* Verify operation in heating and cooling mode
* Inspect refrigerant lines
  + For UV/weather protection
  + Ensure that line wall penetrations are properly air sealed
* Condensate discharge method – confirm location of where condensate will flow to
  + Gravity drain (to floor drain or other)
  + Condensate pumped to drain or exterior
  + Confirm presence of condensate P-trap and vent stack / clean out
  + Drain pan and float safety switch – wires should run into unit to terminate operation if float switch is enabled
* Proper mastic or mastic tape sealant used at all duct connections and AHU penetrations (silicone is acceptable sealant at refrigerant line connections)
* Filters at the AHU are accessible and access covers are temporarily masked/sealed
* Completed (filled out) system install and start-up checklist – provided by contractor
* Manufacturer installation instructions/owner’s manual – usually attached to indoor equipment

### Retrofit New Gas Furnace

A new gas furnace should be a high efficiency condensing gas furnace, likely as part of a ducted system (and usually coupled with a split system air conditioner). A packaged (gas pack) furnace or wall heater may also be encountered. New equipment should be sized via a proper load calculation based on the package of envelope, lighting and internal load improvements.

* Specify that, at equipment change-out, mastic will be applied internally to all accessible joints and collar connections inside the plenum and at all plenum to cabinet connections
* Photograph/record the single model number for the furnace which can be used to verify efficiency via [www.ahridirectory.org](http://www.ahridirectory.org) – please do not confuse the evaporator coil model number with the furnace model number which often requires removal of the louvered panel (this panel does not cover the AHU blower compartment).
* Visually inspect the PVC flue and combustion air pipes – most installations will be two-pipe PVC installations to ensure that combustion air is provided that is separate from surrounding room air. Visually check that the PVC pipe fittings are properly connected with sealant and supported structurally.
* Check the gas line supplying the furnace for a drip leg and confirm that a flexible gas connector does not enter the metal furnace cabinet.
* Check the area around the air handling unit (AHU)
  + for proper duct sealing with mastic (particularly at cabinet and AC coil connections and penetrations)
  + for proper furnace condensate drain – either by pump or floor/gravity drain. If the high efficiency furnace is installed in a cold location, such as a vented attic, steps should be taken to ensure that the condensate will not freeze and shut of the unit (strategies may involve insulation or heat trace/tape on the condensate line)
  + for filter access (if applicable) that is properly sealed (temporarily) but still allows clearance for regular filter change out.
* Turn on system at thermostat and verify performance of the heating system (note, use judgement if outdoor temperature is hot, say 90oF or greater).
* Consider a quick check by counting supply and return duct runs and verifying each register is properly connected (hopefully, the audit identified possible return path problems that have been rectified as part of the upgrade)
* Furnace Systems
* Heating Load calculation
* Fuel type – Natural Gas (or other\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)
* System Manufacturer & Quantity: furnace model number \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* AFUE rating meets minimum 90+% spec (via [www.ahridirectory.org](http://www.ahridirectory.org))
* Flue / combustion venting type
  + Metal, double wall “B-vent” – (invalid, not considered high efficiency)
  + PVC exhaust flue only – (only when outside the building envelope such as a vented attic installation)
  + PVC combustion air in + PVC exhaust flue (most likely)
* Blower type
  + Constant speed (PSC)
  + Variable speed (ECM)
* Condensate discharge method & freeze prevention measures (for condensing furnaces)
  + Gravity drain (to floor drain or other)
  + Condensate pumped to drain
  + Freeze prevention measures \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Filters at the AHU are accessible and access covers are temporarily masked/sealed
* Completed (filled out) system install and start-up checklist – provided by contractor
* Manufacturer installation instructions/owner’s manual – usually attached to indoor equipment

### Retrofit Improved Duct System

All new ductwork must be installed and sealed to meet or exceed minimum code. This means all connections should be sealed with mastic or mastic tape (program recommendations should not permit use of UL-rated or unrated silver tape as a duct sealant). Any ductwork outside the conditioned envelope should be insulated to R-6 (R-8 is required for supplies in a residential unconditioned attic). Ductwork should be:

* Stretched tightly if flexible duct and not pinched or crushed
* Supported properly at maximum 5’ intervals
* Mechanically fastened at all fittings, joints and seams sealed with mastic or mastic tape, and boots sealed to drywall or subfloor
* Trunk and branch design (preferred) – “octopus” systems are not acceptable
* Clear return pathways - these should be visually guaranteed to ensure that each room with conditioned air supplied to it has a pathway for the air to make its way back to the AHU blower
* Utilizing balancing dampers located as specified
* Duct cleaning information, if occasionally specified – consult with others
* Confirm duct sealing method
  + Mastic – minimum 2 mm thickness
  + Mastic tape (no gray or silver tape, UL or otherwise)
* Confirm duct sealing has occurred at proper locations
* Confirm boot penetrations through drywall or subfloor has been caulked or otherwise sealed
* Confirm R-value of duct insulation and that all surfaces (such as boots) are fully insulated
  + R-value of supplies
  + R-value of returns
* Confirm presence of outside air (OA) ventilation and ductwork
  + Outside air (OA) ducts should have an inlet that is not adjacent (typically within 10’) to sources of pollutant or thermal contamination
  + Outside air ducts are required to have a damper (manual or motorized)

### Retrofit HVAC Thermostat

Any new thermostat (t-stat) should ideally be programmable to encourage automatic setback as well as web-based to permit remote monitoring. Explain that, *“A thermostat is not an accelerator pedal. Cranking the heating or cooling setpoint will not make the system respond any faster or affect the temperature of the air leaving the supply registers.”*

* Turn on the unit to at least confirm the operation of the equipment in the seasonally appropriate mode (do not operate cooling if ambient is < 60oF)
* Check the programming to see if the set back is appropriate – (e.g., avoid 6 AM to 6 PM operation unless that is really the schedule)
* Web-based programmable thermostats with lock-out technology and programming schedules that are similar to this:

|  |  |  |  |
| --- | --- | --- | --- |
| Heating Setpoints | | Cooling Setpoints | |
| Occupied | Unoccupied | Occupied | Unoccupied |
| 68°F | 55°F | 76°F | 85°F |

* Train the staff champion and other appropriate individuals about how a thermostat works and how setback saves by not operating equipment when it is not needed
* Teach users how to perform a temporary temperature setpoint override without disturbing the programming or using HOLD
* Confirm that any web-based monitoring features are functioning
* Confirm that the users have recorded any passwords in facility logs

|  |  |  |  |
| --- | --- | --- | --- |
| Actual Heating Setpoints | | Actual Cooling Setpoints | |
| Occupied | Unoccupied | Occupied | Unoccupied |
| \_\_\_\_\_\_°F | \_\_\_\_\_\_°F | \_\_\_\_\_\_°F | \_\_\_\_\_\_°F |

### Retrofit filters

Any new filter upgrade should be greater than 1” in thickness. Three to six inch thick pleated filters are most desirable and options include modifying the ductwork to receive a thicker pleated filter or employing a Practical Pleat type product in the return filter grille.

* Do not accept/allow “air purifiers” that emit ozone
* Be wary of electrostatic filters – their durability is not good and they degrade with time
* Consider [www.anykindoffilter.com](http://www.anykindoffilter.com) as a resource (“AKF003” is a discount code)
* Confirm filter housing/cabinet to duct connections are carefully sealed with mastic
* Verify that filter access panel is temporarily sealed with a magnetic FilterLock type product
* Confirm filter logs are in place to track and maintain regular change-outs

### Retrofit Occupant Ventilation

Ventilation generally can be classified as either local (i.e., spot ventilation such as in kitchens or restrooms) or whole building systems that are intended to provide outside air (OA) to the building occupants.

* If available, all ventilation products should be ENERGY STAR certified (e.g., bath and kitchen exhaust fans) to ensure quiet, efficient operation
  + Exhaust ductwork should be run straight with no kinks or unnecessary loops or bends and shall be exhausted to the outside (not to an unconditioned space such as an attic)
  + Rigid ducting is preferred over flexible when possible
  + When possible, verify the delivered flow by measuring cfm with a flow device
  + Perform the “toilet paper” test to prove that suction occurs at the exhaust grill
  + Automatic controls are encouraged (occupancy sensors, etc.)
  + Use the Model Number to verify ENERGY STAR or equivalent performance
  + Code requires dampers on all intermittent ventilation devices
  + Vent penetrations that are either low to the ground or otherwise enticing as a pest habitat should include a corrosion resistant wire mesh (¼” to ½” in grid size)
* Kitchen exhaust hoods with make-up air systems can be complex – refer to [Food Service Technology Center](http://www.fishnick.com/ventilation/designguides/) for guidance
* Clothes dryer vents shall be fully ducted to the exterior of the building with code approved ducting and mechanically fastened to dryer outlet and exterior wall/roof vent
  + Ideally, dryer vents should not have to push lint upwards
  + Dryer vent termination needs automatically closing cap to prevent pest intrusion and nesting through/in dryer duct
  + Dryer vent envelope rough-opening penetration is fully sealed with spray foam sealant and corrosion resistant wire mesh (¼” to ½” in grid size)
* Central exhaust systems offer the opportunity of energy recovery
* Whole building ventilation systems may be Energy Recovery Ventilation (ERV), Dedicated Outdoor Air Systems (DOAS) or OA ducted into the return; the system should not rely solely on negative pressure strategies
* Demand Control Ventilation (DCV) should be employed in appropriate spaces with variable occupant loads (such as cafeterias, auditoriums, etc.) and sensors ideally located within the breathing zone
* A written narrative of how the whole building ventilation system is intended to operate in compliance with ASHRAE 62.1 provides valuable insight and direction
* Automatic controls shall turn off the ventilation system when the building unoccupied
* Local exhaust systems
  + Restroom
    - Fan model number \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Ducting and termination is acceptable
    - Verify suction at grill
    - Controls are clearly labeled and understandable and function as designed
  + Dryer
    - Ducting and termination is acceptable
  + Kitchen
    - Hood, ducting and termination is acceptable
    - Proper make-up air is supplied
    - Controls are clearly labeled and understandable and function as designed
  + Central
    - Ducting and termination points are acceptable
    - Verify suction at grills
    - Controls are clearly labeled and understandable and function as designed
* Whole building OA system information
  + Type (e.g. ERV, DOAS, OA ducted to return, etc.)
  + Model number \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Efficiency ratings (if available)
  + Demand-based outdoor air ventilation
    - Meets ASHRAE 62.1-2010 minimum ventilation rates based on building occupancy as determined by monitored CO2 levels
    - Sensors located within breathing zone
    - Clearly labeled and accessible controls for temporary ventilation increase
  + Ventilation operation and controls narrative (e.g., continuous, demand based w/ CO2 sensors) and intended operational strategy and schedule

### Retrofit New Water Heater

Most water heaters will be replaced by either new high efficiency condensing gas tank units or with small, locally installed electric point-of-use water heaters (typically with tanks < 10 gallons). It is also possible that condensing gas tankless water heaters will be specified or, in some all electric facilities, a heat pump water heater will be recommended. In general, if natural gas is available, it will provide the cheapest hot water. Combustion water heaters should not receive combustion air from occupant air.

* Water heaters should generally be ENERGY STAR or otherwise meet specified Energy Factor (Ef)
* Heat traps may be specified although most new units contain them
  + Plumbed heat traps (such as loops or inverted U’s) are recommend in multi-story buildings where the water heater is located towards the bottom of the building (e.g., basement)
* All accessible hot water lines should be insulated to minimum R-3
* Confirm that the unit is the correct type and is in the anticipated location
* Check the thermostat – 120oF is desirable as the set point
* Confirm hot water is being produced and arrives at fixtures
* For on-demand recirculation systems,
  + Confirm location of sensor
  + Test for hot water at farthest fixture (record time in seconds)
* For timer-controlled recirculation systems,
  + Confirm location of timer controller
  + Verify setpoints of controller are correct
* For gas water heaters,
  + Check for presence of drip leg at gas valve
  + Inspect combustion venting – should have 2 PVC pipes for condensing equipment (combustion air and flue) that are fully ducted to exterior
* For tank water heaters, verify that drain pans, expansion tanks and T&P valves and lines are installed as per code
* Record water heater model number \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Confirm minimum efficiency rating (Ef) via [www.ahridirectory.org](http://www.ahridirectory.org)
* Activation flow rate for tankless water heaters is at or below lowest water fixture flow (0.5 GPM)
  + Use model number and manufacturer’s specs
  + Confirm operation of lowest flow fixture still activates water heater
* Accessible hot water lines insulated to min R-3
* If removing a gas water heater:
  + Ensure gas line is properly capped
  + Old flue is removed and penetration sealed to match surrounding finishes

### Retrofit Lighting Fixtures and Controls

With little exception, new lighting should be LED or equivalent efficacy. Fluorescent technology contains mercury and does not represent the best environmental choice moving forward. Lighting controls should generally be set to “Vacancy Sensor” mode (manual on, auto off after timeout) but “Occupancy Sensor” mode is appropriate for spaces like restrooms. Also, automatic daylighting sensors are appropriate in well-daylit spaces such as windowed corridors and breakrooms.

Exterior lighting controls should prevent lights from being on during daylit hours and may allow for reduced light levels after curfew hours.

Lighting Source

* Help clients understand that the cheapest lights are not necessarily the best value
* Specify acceptable Kelvin (color temperature) usually between 2700-3000K
* Specify high color rendering index (CRI) – minimum 85, some are 92 (Cree)
* Retrofitting screw in (A-lamp) type fixtures with LED is easy – consider counting or spot checking bulbs from a few fixtures to confirm proper (low) wattage
* Ask clients to rate their satisfaction with original foot candle levels and adjust new lighting retrofits accordingly
* Retrofitting fluorescent fixtures with LED –
  + Consider the cost of LED retrofit tubes plus ballast upgrade for like new fixtures that are in good condition
  + Generally replacing the entire fixture “guts” with an LED driver replacement kit will cost more but still have excellent payback and longer more durable life along with a newer lens and look to the old fixture
* Confirm all exit signs are LED

Lighting Controls

* As a default, all interior lighting controls should be set to vacancy mode with 5-minute time-out delay except for the following locations:
  + Restrooms and shower rooms with occupancy mode with 10-15 minute time-out delay and ceiling mounted sensors
  + Ensure sensor location (wall or ceiling) is appropriate to space constraints
* Dimmable lighting controls as applicable in conjunction with a vacancy sensor
* Corridor lighting offers light level reductions with occupancy and daylight sensing

Exterior lighting:

* Ensure motion controlled sensors have LED lamps and photocell
  + Motion sensor and photocell work together so that light is only on when motion is detected AND daylight is low
* For stairwells, consider LED fixture with bi-level lighting, and photocell and motion sensor control
  + Light is on low level when daylight is low
  + Light bumps up to high level when motion is detected and daylight is low

### Install Efficient Appliances

In general, ENERGY STAR appliances should always be specified if available for a particular appliance type. Generally, seek out appliances that are small (i.e., not oversized) and also those that offer ability to save by completely shutting off during standby mode. When applicable, specify appliances that must meet or exceed a minimum efficiency or other performance spec and consult ENERGY STAR for more guidance. Resources include www.ACEEE.org and www.ENERGYSTAR.gov.

* Appliances
* Type (e.g. residential, commercial, office, etc.)
* Quantity
* Fuel type
* Minimum efficiency ratings
  + Size (e.g. washer, refrigerator)
  + Other pertinent specs
  + ENERGY STAR Labeled? \_\_\_\_\_\_\_\_\_\_\_\_\_
* Pilotless Gas Stove/Oven
* Install comparable commercial gas stove/oven (6 burners or less); oven must be ENERGY STAR labeled or have 44% cooking efficiency and idle energy rate of 13,000 Btu/h or less

### Retrofit Water-Saving Plumbing Fixtures

Specify *WaterSense* labeled fixtures for toilets, flush-valves, showers, spray valves, and faucets. Consult consumer reports or other fixture rating lists to select the best performers.

* Encourage use of high temperature commercial dishwashers (that typically use steam) as they do not require sanitation chemicals
* Consider a spot check to verify low flowrates for several fixtures (recall that fixtures are rated at 80 psig and thus virtually all fixtures will actually achieve lower flows at more typical lower operating pressures of 40-60 psig).
* Check model numbers of installed fixtures to confirm they meet specifications

Water Fixtures

* Type
* Quantity
* Maximum flow rates

Confirm fixture operates as intended and verify presence of aerators (if applicable).