

## EcoVillage Sample Spec Language

Presented here are excerpts from the comprehensive specifications for the EcoVillage Cleveland at W. 58<sup>th</sup> Street. They are offered here as guidance, not as specifications for use on other projects.

1. Within the Bidding Requirements, (Division 00 in Master Short Form Specifications), we included the following under Supplementary Conditions. What's important here is that while no one is going to take anyone to court for a lack of enthusiasm for project objectives, the Owner/Developer is clearly giving priority to and, to the extent possible, holding the Contractor responsible for, the environmental performance of his or her work.

### SUPPLEMENTARY CONDITIONS

The following conditions modify the "General Conditions of the Contract for Construction," AIA Document A201-1997. Where a portion of the General Conditions is modified or deleted by these Supplementary Conditions, the unaltered portions of the General Conditions shall remain in effect.

A. The Eco in EcoVillage Cleveland: This project has a special focus on the environmental sustainability of the design, construction, and operation of the 20 townhouse units. The following conditions make explicit the expected responsibility the Contractor shall assume in working with both the Owner and the Owner's representatives to minimize the environmental footprint of both the construction process and the ultimate performance of the buildings after construction is complete and the units are occupied:

1. Systems Thinking Approach to Construction: The efficient performance of the EcoVillage Cleveland buildings is critically dependent on each trade being aware of the impact that their work has on other trades. The Contractor must work closely with the Architect and the trade contractors to fully implement all details on the Drawings and the Specifications. The added care and detail in the Drawings and Specifications must be reflected in the added care and detail of the work on site.
  2. Construction Team Communication: The superior building performance discussed above can only be achieved through open and steady channels of communication among all members of the Construction Team—Site Superintendent, Architect, Engineer, and site personnel.
  3. Material Selection: The energy and resource efficiency of EcoVillage Cleveland involves the specification of many alternative building materials and systems. The Contractor and his Subcontractors shall work with the Owner and the Architect to obtain and properly install these materials and systems.
  4. Waste minimization: From site clearing to final clean-up, this project seeks to reduce waste first, and then recycle as much of the waste generated as is possible. The Contractor and his Subcontractors shall work with the Owner and the Architect to achieve the lowest waste generation rate possible.
  5. Education: Work with Owner to participate and cooperate with on sight educational workshops.
2. Within Division 1, General Requirements, we wrote the following. Note that this is a follow-up on the Contract language relating to environmental performance in the Supplementary Conditions of the Bidding Requirements. And since there is a

requirement for the General Contractor to supply all subcontractors with copies of Division 1 General Requirement, everyone working on the project should be aware of the environmental performance aspects of the project.

## PART 1 - GENERAL

### 1.01 SUMMARY

#### A. Particular Project Requirements:

1. Resource efficiency – All contractors must comply with the resource efficiency efforts that the EcoVillage Cleveland project embodies. In design; selection of systems, methods, and materials; and waste management; this project will minimize its environmental impact through efficient use of materials, energy-efficient operation, and long-term durability. Areas of special focus include:
  - a. Efficient framing.
  - b. Sustainably harvested wood—framing, finish, cabinetry.
  - c. High fly-ash/blast furnace slag content cementitious materials—poured concrete, concrete block.
  - d. Energy efficiency—envelope design details and materials, and HVAC system design and materials.
  - e. Durability—envelope design details, exterior and interior finishes.
  - f. Waste management—on-site recycling of landclearing materials and drywall, off-site recycling of cardboard, metals and other materials.
  - g. Salvaged materials—brick pavers, interior non-load bearing partition members.
  - h. Indoor environmental quality – ventilation systems, actively vented combustion sources, selection of materials and systems from a human health perspective.

And:

#### B. Coordination:

1. Coordinate the work of all trades. Superior energy performance and long-term durability of these buildings requires extra attention to the coordination of work on-site.
2. Provide Division 1 specifications to all subcontractors. Copies of the reference “Builder’s Guide Cold Climate” have been provided as it is referenced throughout the specifications. All subcontractors must receive a copy of Division 1 – General Requirements with relevant sections and Drawings. All specifications have been provided to the Contractor on a compact disc for trade-specific printing of all specifications.

And, for construction waste management under Temporary Controls and Facilities, we wrote the following. Note that low-value construction waste materials such as clean wood and drywall that typically lack markets can be successfully and beneficially employed on site.

## PART 3 - EXECUTION

### 3.01 CONSTRUCTION WASTE MANAGEMENT

- A. The following materials shall be recovered from the construction waste stream, to be processed and used on site or recycled:

Site Materials:

1. woody landclearing material.
2. masonry and concrete discovered below grade during excavation.
3. excavated soil.

Construction materials:

4. clean wood (solid sawn and engineered wood material, not including painted, stained, or treated wood of any kind).
  5. gypsum board cut-offs
  6. cardboard packaging
  7. Metals – steel, copper, and aluminum
- B. For site materials, Contractor will work with waste management firm on most efficient use of site materials, either processing and use on site for soil erosion control and soil amendment, or reuse/recycling at closest site or facility to project.
- C. For construction materials, Contractor will work with waste management firm to either site separate materials into individual containers (site space permitting), or use general containers for commingled recovery. If markets for wood and drywall waste are not available, site processing and use for erosion control and soil amendment will be pursued.

3. In Division 2 – Site Construction, we wrote the following for paving, driveways and walkways. Note that the necessary technical information for pervious concrete is supplied in the specs in a reference document and that the actual source of the less-than-conventional salvaged pavers is right in the spec:

### 1.02 SUBMITTALS

- A. Pervious Concrete Design Mix: Submit for approval design mix, including adjustments for variations in project conditions.
- B. Product Data: Submit manufacturer's product data and installation instructions for each material and product used. (Pavers: Submit representative samples of salvaged brick pavers for aesthetic and physical properties evaluation.)
- C. Submit extra stock (pavers) equal to 2% of total product used.
- D. Test Reports: Submit for approval test reports.

### 1.03 QUALITY ASSURANCE

- A. Construction Tolerance: 1/8" in 10' for grade and alignment of top of forms; 1/4" in 10' for vertical face on longitudinal axis.

## PART 2 - PRODUCTS

### 2.01 MATERIALS

- A. Pervious Concrete:

1. 6" porous concrete (AASHTO #87 aggregate) no fines
  2. 4"-5" of AASHTO #67 Stone aggregate
  3. 4"-5" of compacted sand
  4. Compacted subgrade to 92%-95% modified proctor..
  5. Additives:
    - a. Type A Water Reducing Admixtures shall comply with ASTM C 494
    - b. Type B Retardation Admixtures shall comply with ASTM C 494
    - c. Type D Water Reducing/Retarding Admixtures shall comply with ASTM C 494
- B. Curbs and Gutters: Pre-cast concrete, coordinated and approved by local authority having jurisdiction. ASTM C 150, Type I, Portland Cement; ASTM C 33, normal weight aggregates; potable water.
- C. Unit Pavers:
1. Salvaged brick sourced from Kurtz Brothers, Inc. (PH: 216/986-7000) or approved equal.
  2. UngROUTED mortarless setting bed over filter fabric and stone dust bed and prepared subbase.
  3. Hand-tight joints with stone dust filler.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Pervious Concrete Pavement: Refer to Design Criteria Appendix: "Pervious Concrete Specifications"
3. In Division 3 – Concrete, we wrote the following specifications for concrete with high substitution of blast furnace slag or flyash for Portland cement. Lots of technical and logistics research was done BEFORE the spec was written to ensure that the less-than-conventional use of high percentages of slag and flyash were both technically and logistically feasible.

### PART 2 - PRODUCTS

#### 2.01 MATERIALS

- A. Portland Cement: ASTM C 150, Type I/II.
- B. Ground Granulated Blast Furnace Slag: ASTM C989, Grade 100 or 120
- C. A. and B. Above or Blended Hydraulic Cement: ASTM C 595M, Type IS, Portland blast furnace slag cement, or ASTM C 1157.
- D. Normal-Weight Aggregate: ASTM C 33, uniformly graded as follows:
  - a. Class: Moderate weathering region, but not less than 3M.
  - b. Nominal Maximum Aggregated Size: 1inch (25 mm).
  - c. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 8 percent may be retained on coarsest sieve and on No. 50 (0.3-mm) sieve, and less than 8 percent may be retained on sieves finer than No. 50 (0.3 mm)
- E. Water: Potable and complying with ASTM C 94.

## 2.02 CONCRETE DESIGN MIXES

- A. Footings: Compressive Strength: 2500 psi, 56-day ultimate strength, no entrainment; Slabs on Grade: Compressive Strength of 4000 psi., 56-day ultimate strength, 6% air entrainment.
- B. Portland Cement: ASTM C 150, Type I/II.
- C. Ground Granulated Blast Furnace Slag: ASTM C989, Grade 100 or 120
- D. A. and B. Above or Blended Hydraulic Cement: ASTM C 595M, Type IS, Portland blast furnace slag cement, or ASTM C 1157.
- F. Normal-Weight Aggregate: ASTM C 33, uniformly graded as follows:
  - a. Class: Moderate weathering region, but not less than 3M.
  - b. Nominal Maximum Aggregated Size: 1inch (25 mm).
- E. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 8 percent may be retained on coarsest sieve and on No. 50 (0.3-mm) sieve, and less than 8 percent may be retained on sieves finer than No. 50 (0.3 mm)
- F. Formwork: Reusable metal panel formwork or approved equal sufficient for structural and requirements.
  - 1. Form release agents:
    - a. Form release agents shall be delivered in manufacturer's sealed and trademarked containers.
    - b. Form release agents: Vegetable-based form release only. Do not use petroleum solvents such as creosote or diesel oil. Paraffin and waxes shall not be used when a concrete finish is required.
- G. Subslab Materials:
  - 1. 3/4-inch gravel, 4 inches deep
  - 2. Rigid insulation: 2-inch EPS
  - 3. Sub-slab ventilation stack stub: 3-inch PVC "T" set in upper surface of gravel bed, 4-foot lengths of perforated pipe attached to "T". 3inch pipe stub extends up through the slab pour. See Drawings for locations. (Reference: *Builder's Guide: Cold Climate*, 5<sup>th</sup> edition, 2001, Figure 4.5, page 39.)
- H. Finishes:
  - 1. Interior Concrete – smooth steel troweled. Alternative finish - give unit price, pigmented surface treatment on slab-on-grade units and basements. (For example, see Davis Colors; Los Angeles, CA; PH: 800/356-4848; [www.daviscolors.com](http://www.daviscolors.com).)
  - 2. Exterior Concrete – Broom finish

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Refer to Drawing detail for subslab insulation, sub-slab ventilation, and sub-slab drainage (Reference: *Builder's Guide: Cold Climate*, 5<sup>th</sup> edition, January 2001, Figure 4.9, page 45).

- B. Continuous damproofing or flexible membrane shall be installed over the top of the footings per the Drawings (Reference: *Builder's Guide: Cold Climates*, 5<sup>th</sup> edition, January 2001, Figure 4.10, page 44).
- C. All steel reinforcing rods and mesh shall be installed prior to pouring and all steel shall be adequately supported to allow for proper finish.
- D. No water shall be added on-site to increase the workability of concrete. Use only plasticizer to make concrete more workable.
- E. Slabs shall receive a minimum of one control joint in each direction.
- F. Apply 20% curing compounds on all interior slabs—compound must be compatible with interior floor finish materials.
- G. High-Volume Blast Furnace Slag/Fly Ash Concrete:
  - 1. Concrete mixes containing high-volume slag/fly ash generally take longer to reach full strength. Specify 56-day ultimate strength compliance instead of 28-day strength.
  - 2. Do not add water to designed and delivered mix. Note that for interior slabs in particular, this requires greater care and timing control when finishing.
  - 3. Provide protection against drying during curing.
  - 4. Avoid installing in cold conditions (see H below).
  - 5. In freeze-thaw conditions, increase air-entraining admixture for fly ash with high carbon content.
- H. Cold Weather Concrete Work:
  - 1. Cold weather, for the purpose of concrete pouring, is defined by the occurrence of the following conditions for more than 3 consecutive days:
    - a. average daily air temperature is less than 40°F, and;
    - b. air temperature is not greater than 50°F for more than one-half of any 24-hour period.

Pouring concrete under cold weather conditions as defined above requires submittal by the contractor of a plan to the owner prior to the work.

5. In Division 6 – Wood, we wrote the following specifications for rough carpentry. Note that for each less-than-conventional type of material, specific contact and/or reference information is provided.

#### 1.02 QUALITY ASSURANCE

- A. Lumber Standards: PS20 American Softwood Lumber standard and applicable grading rules of inspection agencies certified by American Lumber Standards Committees (QLSC) Board of Review.
- B. NEW DIMENSIONAL LUMBER - CERTIFIED: Certified to be from a Well Managed Forest by the Forest Stewardship Council or from salvaged or rediscovered timber per the SmartWood Certification Program. Example regional sources include:
  - 1. D. Stubby Warmbold; Ewing, NJ; 609/538-8680.
  - 2. Materials Blanchette; Quebec City, Canada; 418/871-2769
  - 3. Menominee Tribal Enterprises; Neopit, WI; 715/756-2311

And:

## 2.02 MATERIALS

### A. Lumber:

1. Dimension Lumber: Nominal sizes, dressed S4S, maximum 19% relative moisture content, unless otherwise indicated.
2. Light framing (2 – 4 inches thick, 2 – 4 inches wide): No. 2 pine or spruce fir (or equal)-FB, 800 psi min.
3. Structural framing (2 – 4 inches thick, 5 inches and wider): No. 1 grade douglas fir or spruce fir (or equal), FB 1200 psi min.
4. Non-load-bearing framing: Salvaged two-by-four stock or approved equal. Sources include:
  - a. Catellier Salvage & Wrecking Inc.; Camby ,IN; PH: 317/831-4533; FX: 317/834-3057
  - b. Kurtz Brothers; Cleveland, OH; PH: 216/986-7000
5. Pressure-treated (any framing in contact with masonry or moisture): ACQ (ammoniacal copper quaternary) or Copper Azole, if available or can be purchased as part of framing package. Avoid CCA- and ACA-treated lumber (chromated copper arsenate and ammoniacal copper arsenate).

And:

- B. Underlayment: 1/4-inch or 3/8-inch, IsoUnderlay or sanded and plugged plywood; carpet- or resilient flooring-ready. Luaun is not acceptable. (Isobord Enterprises, PH: 503/242-7345, [www.isobord.com](http://www.isobord.com)). Distributors include:

1. Alpine Plywood – Wisconsin, PH: 414/438-8400
2. Atlantic Plywood – Connecticut, PH: 860/291-8020
3. Georgia-Pacific –Georgia, PH: 770/221-2548

- C. Exterior Exposed Decking (Balconies and back porch/steps): Wood-plastic composite 5/4 X 6 material, including:

1. Trex Easy Care Decking - Winchester, VA; PH: 800/289-8739; [www.trex.com](http://www.trex.com).
2. SmartDeck , U.S. Plastic Lumber – Chicago, IL; PH: 800/653-2784, [www.usplasticlumber.com](http://www.usplasticlumber.com).
3. NexWood, Composite Technologies Resources – Brampton, ON; PH: 888/763-9966; [www.nexwood.com](http://www.nexwood.com)
4. StranDek – Meridian, ID; PH: 877/446-3030; [www.strandek.com](http://www.strandek.com)

6. Within Division 13 – Special Construction, we wrote the following specs for Solar Energy Systems. Although only referenced here, the Contractor is being provided with ALL of the details he or she will need to install the roof top systems, down to the custom-engineered mounting brackets.

## PART 1 - GENERAL

### 1.01 SUBMITTALS

- A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

- B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.
  - 1. Shop drawings shall be prepared and stamped by a qualified engineer licensed in the jurisdiction of the project.

#### 1.02 QUALITY ASSURANCE

- A. Comply with governing codes and regulations. Provide products of acceptable manufacturers that have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.
- B. PV panels:
  - 1. Modules must be UL listed to UL1701, have a minimum 20-year warranty
  - 2. Power conditioning unit must have continuous AC kW output capacity of no less than 80 percent of the array STC rating, must be UL listed to UL1741, and must comply with IEEE 929 standard for utility interconnection.

### PART 2 - PRODUCTS

#### 2.02 MATERIALS

- A. Roof-mounted photovoltaic system: (AstroPower or approved equal) Panels, mounting system, utility interconnection equipment with delivery of 2.4-3.2 kW as tested at Standard Test Conditions (STC). System must meet the following conditions:
  - 1. Modules must be manufactured from crystalline silicon solar cells.
  - 2. Must be capable of Maximum Power Point Tracking (MPPT) the PV array.
  - 3. Must include option for an outdoor rated enclosure (NEMA 3R minimum).
  - 4. Support structure or module attachment system must be approved by a professional engineer.
  - 5. Must provide kW and kWh used by the home's loads to the homeowner
  - 6. Must provide kW and kWh generated by the PV system to the homeowner

Preference will be given to bids that include components that are manufactured from recycled materials and/or include components that are manufactured using energy generated from renewable resources. Preference will be given to bids that are designed to use "plug and play" components.

- B. Roof-mounted solar hot water system: All specifications for this optional system are contained in the separate document, "Request for Proposals for Solar Water Heating System for EcoVillage Cleveland – Building Science Corporation."

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install materials and systems in accordance with manufacturer's instructions, approved submittals, and per electrical specifications/drawings. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Provide proper clearances for servicing.
- B. Test all systems for proper operation.

7. Within Division 15 – Mechanical Systems, we wrote the following for HVAC. You won't find many specs with this level of detail about equipment and materials, system integration of the heating, cooling and ventilation, nor specific requirements for performance testing.

#### SECTION 15530 – FURNACES

- A. EQUIPMENT – 90%+ AFUE sealed combustion, installed in conditioned space (basement). See Design Criteria Appendix for more information.
- B. INSTALLATION – Installed per the Center for Energy Efficiency's (CEE) "Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems." ([www.CEEforMT.org/resid/rs-ac/hvac.php3](http://www.CEEforMT.org/resid/rs-ac/hvac.php3))

#### SECTION 15670 – REFRIGERANT CONDENSING UNITS

- A. Equipment – 12 SEER Air Conditioner Split System. See Design Criteria Appendix for more information.
- B. INSTALLATION – Installed per the Center for Energy Efficiency's (CEE) "Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems." ([www.CEEforMT.org/resid/rs-ac/hvac.php3](http://www.CEEforMT.org/resid/rs-ac/hvac.php3))

#### SECTION 15900 – HVAC CONTROLS

- A. EQUIPMENT
  - 1. AirCycler™ supply-only system integrated with the AHU (return side), 30-40 CFM continuous average flow, 33% duty cycle (e.g., 10 on; 20 off).
  - 2. Programmable thermostat.

#### SECTION 15800 - AIR DISTRIBUTION

##### 1.1 MATERIALS:

- A. Low Pressure Ductwork: Ductwork shall be 24 gauge galvanized and insulated per local code requirements.

##### 1.2 EQUIPMENT:

- A. Exterior Louvers
  - 1. Provide stormproof exterior wall louver, size as indicated on plans.
  - 2. Louvers shall be Ruskin, Model ELF-375, 4" deep, stormproof, extruded aluminum, with 1/2" square mesh aluminum screen on interior face.
  - 3. Equivalent louvers by Titus or Construction Specialties are acceptable.
- B. Wall Caps  
Nutone or equal aluminum brick vent type wall cap or hood, aluminum construction with backdraft damper.
- C. Exhaust Fans  
Panasonic Advanced Ventilation Series, FV-05VQ (note: 50 cfm, 0.5 sone, and 13.2 watts for approved equal), surface mounted, ceiling exhaust fan, 120 Volt 1 Phase. Provide with backdraft damper. Wire to wall switch.
- D. Kitchen Hoods  
High efficiency 100 cmf ducted range hood. VenMar or approved equal. VenMar Ventilation, Inc. Ph: 1-800-667-3717.

1.3 INSTALLATION:

- A. Install all ducts in conditioned space per the Drawings. NOTE: Outside air supply duct shall be tied into the return duct of the air handler with the in-line flow regulator.
- B. All ducts and joints at the air handler and plenum shall be sealed with duct mastic. Coordinate electrical hook-up with Electrician under another contract.

SECTION 15950 – HVAC TESTING

- A. **QUALITY ASSURANCE:** The following HVAC tests shall be performed at stages of construction that allow the most opportunity for remedy of unsatisfactory results (For more detailed discussion of the testing requirements, refer to Design Criteria Appendix):
  - 1. Blower Door Test – acceptable air leakage is 2.5 square inches of equivalent leakage area per 100 square feet of envelope area or less.
  - 2. Duct Blaster Test – Acceptable duct leakage to the outside is 5% of the high-speed air handler nominal flow, at 400 CFM per ton or less.
  - 3.

**DESIGN CRITERIA APPENDIX**

**Building Characteristics**

- A. The following building envelope and mechanical system characteristics were used in our energy models and calculations. If these are inconsistencies in these specifications, they should be pointed out to Building Science Corporation ASAP.

**Building envelope**

Ceiling	R-38 (insulation type unknown)
Walls	R-19 24 oc + R-5 XPS exterior @ brick R-19 24 oc + R-4 EPS exterior @ stucco R-19 24 oc + R-5 XPS/R-4 EPS
Band joists	exterior
Foundation	R-10: 2" EPS on basement walls w. GWB 2x3 framing, assume no cavity insulation
Slab	R-4 3/4" EPS on basement to slab wall R-8 2" EPS under entire slab
Depressed patios	R-10 2" XPS 4' wide frost protection Double-glazed low-emissivity wood
Windows	frame

(vinyl clad) U=0.36, SHGC=0.45  
 2.5 sq in leakage area per 100 sf  
 Infiltration envelope

**Mechanical systems**

Heat 90%+ AFUE Sealed-Combustion Furnace  
 in conditioned space (basement)  
 Cooling 12 SEER Air Conditioner Split System  
 0.59 EF Power-Direct Vent Water  
 DHW Heater  
 (40 gallon) in conditioned space  
 (basement)<sup>1</sup>  
 Ducts In conditioned space  
 Duct Leakage none to outside (5% or less)  
 Ventilation AirCycler™ Supply-only system  
 integrated with AHU (return side)  
 30-40 CFM continuous average flow  
 33% duty cycle (e.g., 10 on; 20 off)  
 Pressure relief Transfer grilles/jump ducts at bedrooms

Details and explanations on the ventilation system, and pressure relief/transfer grilles are enclosed.

1: This assumes the installation of an A.O. Smith Sealed Shot unit; State manufactures a unit that will meet our specification, but has a lower efficiency. Details can be found in Appendix C.

1. Design Loads

The heating and cooling design loads were calculated with RHVAC, a computerized version of Manual J, the ACCA industry standard load calculation method. The party walls (between units) were not computed as “adiabatic” for heat loss (i.e., no heat loss or gain). Instead, they were computed as partition walls with a 10° F temperature difference (e.g., in winter 70° F indoors, 60° F in the interstitial cavity). Resulting loads were as follows:

Plan	Nominal floor area	Stories	Design Heating	Sensible Cooling	Latent Cooling	Total Cooling
End Slab	1604	2	20.2	16.2	2.3	18.5
Middle Next to Slab	2396	2	23.0	20.5	3.8	24.2
Middle Next to Bsmt	2415	2	22.0	19.7	3.8	23.5
End Bsmt Upper	1666	2	22.4	21.4	3.1	24.5
End Bsmt Lower	833	1	12.6	7.3	2.0	9.4

Calculations were done with the following design conditions for Cleveland, OH:

Winter design temperatures: indoor 72° F, outdoor 5° F, ΔT = 67° F

Summer design temperatures: indoor 75° F, outdoor 90° F, ΔT = 15° F  
 Equipment Sizing: Cooling

The drawings are set up with cooling equipment as follows:

Plan	Nominal floor area	Stories	Specified
			Tons A/C
End Slab	1604	2	2.0
Middle Next to Slab	2396	2	2.5
Middle Next to Bsmt	2415	2	2.5
End Bsmt Upper	1666	2	2.5
End Bsmt Lower	833	1	1.5

Although the End Slab and End Basement Upper units are close to the same size (square footage, 2 stories), the latter has a ½ ton larger system. This is due to the greater window area of the End Basement Upper unit; a large portion of cooling load (typically 40-50%) comes from the windows.

The End Bsmt Lower unit could be cooled by a 1-ton unit; however, the smallest typically available size condenser is a 1-½ ton unit.

#### 1. Equipment Sizing: Heating

Given the relatively low loads of these units, the smallest capacity furnaces available will suffice (typically 40,000 Btu input units). For combustion safety and efficiency reasons, we require a sealed combustion/direct vent condensing gas furnace (e.g. Carrier 58MXA series; specification sheet enclosed). Sample sizings are shown below:

Plan	Nominal floor area	Carrier Unit	Input Btu/hr	Nom. Cool. Airflow
End Slab	1604	58MXA-040-130-08	40,000	895 CFM
Middle Next to Slab	2396	58MXA-040-130-12	40,000	1215 CFM
Middle Next to Bsmt	2415	58MXA-040-130-12	40,000	1215 CFM
End Bsmt Upper	1666	58MXA-040-130-12	40,000	1215 CFM
End Bsmt Lower	833	58MXA-040-130-08	40,000	895 CFM

The airflows shown are at 0.5 external static pressure (W.I.C.), at high speed.

Note that these units are shown as an example; favored brands of the builder or HVAC contractor can be substituted, assuming they meet the heating and cooling loads, airflow requirements (400 CFM per ton nominal), and combustion safety requirements (sealed combustion/direct vent).

#### Limitations of Sizing Strategy

The equipment sizing assumed certain attributes of the house. If the house is not built within these parameters, heating and cooling performance problems may result.

- Airtightness: the air infiltration requirements for the units are stated below (see Appendix A, Test Requirements). The Manual J calculations assume an air change rate of 0.1 natural ACH; this has been measured in various Building America level houses across the country.

- Duct leakage: the duct blaster test requirements are shown below (see Appendix A). The leakage that will be measured and compared to the goal is duct leakage to outside. However, we also have a program-wide recommendation that total duct leakage should not exceed 10% of nominal system flow, if possible.
- Windows: the high-performance, low-E, wood frame (vinyl clad) windows must be used (U=0.36, SHGC=0.45). This item is one of the keys to occupant comfort. Furthermore, a common failure is that the IGU (insulated glass unit) is installed backwards at the factory. The low-emissivity coating should be on the inner surface of the inner pane of glass (surface 2, counting from inside to outside). An example of a glass testing unit can be seen at <http://www.edtm.com/ae1600.htm>
- Setback performance: on the cooling side, this equipment is sized to maintain the house at temperature setpoint, not to bring it from 95° F indoors down to 75° F during peak afternoon loads. Therefore, large temperature set-ups (with a setback programmable thermostats) should be avoided; 3-5° F should be used, maximum.

With the efficient envelope and ducts within the conditioned space, maintaining the house at setpoint during the day is a more economical way to run the house than to let it heat during the day then cool it down. This is called our “set it and forget it” philosophy.

### 3.02 Test Requirements

Infiltration/air flow retarder (a.k.a. air barrier): The envelope is tightened to a target based on the surface area of the house (including floor slab). The Building America target is 2.5 square inches of equivalent leakage area per 100 square feet of envelope area.

The airtightness of these test houses will be measured with a blower door test. The targets are shown in the table below, in CFM 50 (cubic feet per minute at a test pressure of 50 Pascals) and in ACH 50 (air changes per hour at 50 Pascals). Note that ACH 50 is not the same as natural air changes per hour (nACH).

<b>Plan</b>	<b>Nominal floor area</b>	<b>Stories</b>	<b>Surface area (ft<sup>2</sup>)</b>	<b>Volume (cu ft)</b>	<b>Goal CFM 50</b>	<b>Goal ACH 50</b>
End Slab	1604	2	4,015	13,634	1000	4.4
Middle Next to Slab	2396	2	4,961	19,977	1240	3.7
Middle Next to Bsmt	2415	2	4,982	20,125	1250	3.7
End Bsmt Upper	1666	2	4,197	14,161	1050	4.4
End Bsmt Lower	833	1	2,891	6,664	720	6.5

Duct system: The ductwork system will be tested for tightness in the completed house with a duct blaster test. The goal is a CFM 25 (cubic feet per minute at 25 Pascals test pressure) equal to 5% of the high-speed air handler nominal flow, at 400 CFM per ton. For instance, a 3-ton unit has a nominal 1200 CFM flow, with a 60 CFM 25 goal. This requirement is for duct leakage to the outside, not total duct leakage.

This table also shows square feet per ton; a common sizing metric used by HVAC contractors. These numbers are higher than typically seen numbers; this is due to the tighter sizing strategies that we used, as well as the improved building envelope. The low square footage per ton for the End Basement Lower unit is due to the fact that a 1-ton capacity unit is not available; 1.5 is the smallest available.

**Nominal                  Specified Duct leak**

<b>Plan</b>	<b>floor area</b>	<b>Tons A/C</b>	<b>(CFM 25)</b>	<b>sf/ton</b>
End Slab	1604	2.0	40	802
Middle Next to Slab	2396	2.5	50	958
Middle Next to Bsmt	2415	2.5	50	966
End Bsmt Upper	1666	2.5	50	666
End Bsmt Lower	833	1.5	30	555