DIVISION 15
MECHANICAL

SECTION:

15.1 GAS PIPING SYSTEMS
15.2 PLUMBING AND DRAINAGE
15.3 PLUMBING FIXTURES, EQUIPMENT AND ACCESSORIES
15.4 DOMESTIC HOT WATER*
15.5 SPACE HEATING – GENERAL*
15.6 VENTING OF WATER HEATERS AND HOUSE HEATERS*
15.7 WARM AIR FURNACES*
15.8 COMBINATION WARM AIR / DOMESTIC HOT WATER SYSTEMS
15.9 DUCTWORK
15.10 HOT-WATER BOILERS*
15.11 HYDRONIC HEAT DISTRIBUTION SYSTEMS
*(15.12, 15.13 – SEE HIP APPENDIX)**
15.14 CENTRAL AIR CONDITIONING
15.15 TESTING, ADJUSTING AND BALANCING
15.16 EXHAUST VENTILATION SYSTEMS

* *See the **HIP Appendix** for additional provisions which apply only to home repair and partial-rehab programs.*

SECTION 15.1 GAS PIPING SYSTEMS

15.1 A **Materials:**

1. Schedule 40 black steel with black malleable iron screwed fittings conforming to ASTM 453.
2. Corrugated stainless steel tubing for interior gas piping as approved by PGW.
3. Fittings for corrugated stainless steel tubing as approved by PGW.

15.1 B **Execution:**

1. Contractor shall arrange with PGW for gas service and meter installation and follow all codes and regulations required by PGW. New service shall be sized in accordance with PGW recommendations for gas equipment consumption and length of run.
2. Provide shut-off valves at all equipment and at meter.
3. Testing for leaks shall conform to PGW standards.
4. Flexible tubing shall not be used to connect the house heater or water heater.

SECTION 15.2 PLUMBING AND DRAINAGE

15.2 A **General:**

1. Work Included –
   a. Alterations and additions to the sanitary water drainage systems, including a new house drainage system, house trap, new lateral from trap to fresh air inlet, new fresh air inlet and cleaning of the existing lateral from the curb to the City sewer.

b. Curb shut off valve and valve box, serving line, meter, hot water heater, piping and accessories.

c. All plumbing fixtures and connections thereto.

d. Gas service including piping, accessories, and arrangement with PGW for connection to City main, meter installation and service.

e. Excavation and backfilling in connection with work under this section.

f. Cutting in existing work required and cost of patching same.

g. Cleaning, testing, balancing, adjusting and performance tests for all equipment and materials furnished or installed under this Section.

h. Connection of downspouts to drainage system, including downspouts previously in common with neighboring property, and new or existing porch, bay or shed downspouts.

2. Requirements –

a. Materials and Equipment: All materials and equipment shall be new, and of the latest design. All apparatus shall fit into available spaces in the structure. All equipment normally requiring service shall be accessible.

b. Visit to the Site: The Contractor shall have visited the site and have determined all conditions on which work is in any way dependent and shall have made all provisions necessary for the best workmanship and operation of plumbing systems. No consideration or allowance beyond the Contract sum will be granted for failure to visit the site and so act.

c. Codes, Rules, Permits, Fees: All work shall be done in accordance with all applicable codes, laws, ordinances, rules and regulations. The Contractor shall obtain all permits and inspection certificates and pay all fees.

d. Testing and cleaning piping systems: After erection, all piping systems shall be inspected, tested for leaks and proven tight. All foreign substances which may have accumulated in the systems during installation shall be completely removed. Domestic water piping shall be cleaned in accordance with the City Code and AWWA C601.

e. Pipe and fitting materials shall conform to the latest issue of American Standards Association (ASA), American Society for Testing Material (ASTM), and American Water Works Association (AWWA).

15.2 B **Products and Systems:**

1. Sanitary waste, Vent and Rainwater Drainage Systems –

a. Minimum house drain, house trap, and fresh air inlet at curb shall be 4 inches. Normal slope of drain line shall be 1/4 inch per foot. Use 1/8 inch per foot slope only if sewer connection cannot be made at normal slope and only with prior approval from L&I.

b. Clean out shall be provided at the base of each stack and in main drain line at 90 degree turns, at front of house, and not more than 50 ft. apart.

c. Where combination storm/sanitary sewers are present, all rain water stacks shall have deep seal traps at base, inside basement.

2. Waste System Piping Materials –

a. Underground piping serving conventional fixtures and underground rainwater piping shall be uncoated service weight, cast iron bell and spigot pipe and fittings conforming to ASTM A74.

b. Above-ground soil pipes, drains and vents shall be ABS Schedule 40, or PVC Schedule 40.

c. Exposed piping at fixtures shall be chromium plated threaded brass pipe and fittings conforming to ASTM B43.

3. Domestic Water Piping Systems –

a. Contractor shall be responsible for water meter installation in accordance with the Water Department Standards but in no case less than 5/8 inch in size.

b. Minimum water service size shall be 3/4 inch.

c. Minimum water supply pipe size shall be as follows:

To each living unit, hot water heater, first branch off: 3/4 inch.

Branch supplies to fixtures: 1/2 inch.

4. Domestic Water Piping System Materials –

a. Underground water service shall be type "K" copper with cast brass or wrought copper fittings conforming to ASTM B88.

b. Above ground piping shall be type "L" copper with wrought copper fittings conforming to ASTM B88.

c. Exposed piping at fixtures shall be bright chromium plated threaded brass tubing and fittings conforming to ASTM B43. (Piping inside vanity or kitchen cabinets is not considered to be "exposed.")

15.2 C **Execution:**

1. Install all plumbing in strict compliance with manufacturer's instructions. Provide complete operating systems, furnish all necessary fittings, valves, hangers, supports and specialties required, and run all piping in a workmanlike manner in accordance with the best practice of the trade and the latest code requirements.
2. Support soil line in basement from clevis hangers or on stuccoed, solid masonry piers.
3. Soldered joints shall be fully sweated and wiped clean.
4. PVC and ABS joints shall be fully bonded with correct sealant.
5. Leaded joints shall be fully leaded and packed to consolidate lead.
6. All piping above the basement shall be concealed, except that to individual fixtures.

SECTION 15.3 PLUMBING FIXTURES, EQUIPMENT, AND ACCESSORIES

15.3 A **Fixtures:**

1. Finish - general: faucets, valve controls, drain assemblies and other fittings shall be chromium-plated brass; absent express permission from PHDC/RDA, all fixtures shall be white.

2. Toilets: all new toilets shall use not more than 1.6 gallons per flush, as required by Federal regulation.

3. Bathroom Lavatory: "Cultured Marble" top similar to Chelten Mfg. Model #2522, single lever faucet with pop-up drain (Valley model #830 or Delta #520 or #522), lavatory supply

assembly and trap, 1-1/4 inch min. drain, vanity cabinet base 21 inches by 24 inches minimum unless otherwise noted on construction documents or preapproved by PHDC/ RDA. See Division 11 for vanity base requirements.

4. Bathtub: American Standard 0134.130 (right outlet) or 0134.135 (left outlet) "Solar"enameled steel tub 60 inches L x 30 inches W x 16-1/4 inches H with Valley 431 single-lever or Delta 636 bath/shower fitting valve, diverter spout and pop-up drain assembly. Tub must have bottom foam support. Install tub trap and 1-1/2 inch drain.

5. Showerheads: All new showerheads shall use not more than 2 gal./minute at 40 psi.

   Acceptable model: Niagara N2130

6. Kitchen Sink: 20 ga. stainless steel, one-bowl 25 inch: Federal or Just "Continental" series with American Standard 4200-010 "Aquarian" fitting and 1-1/2 inch drain.

7. Faucet: Single lever Valley model L103-8, or Delta #522, #520, #100.

8. Hose Bibb: Nibco 1/2 inch frost free sillcock, bronze with hose end connection. Mount 16 inches above grade. Provide interior stop in basement.

15.3 B **Trim and Accessories:**

1. All fixtures shall be furnished with necessary fittings, escutcheons, bolt caps, traps, piping and stop valves.

2. Traps for lavatories and sinks may be PVC if concealed in a cabinet; otherwise shall be tubular adjustable chrome plated.

3. Each fixture shall be provided with a stop valve placed close to the fixture to permit the line to the fixture to be shut off separately.

4. Chrome escutcheon plates shall be provided on all exposed piping passing through floors, walls or ceiling.

15.3 C **Execution:**

Furnish and install complete all fixtures and equipment with all necessary water supply and soil and waste piping to sanitary drainage system.

SECTION 15.4 DOMESTIC HOT WATER

15.4 A **Integral Hot Water Heaters:**

1. Hot water heaters (HWH) shall be gas-fired, rated Energy Factor not less than 57%, with anti-convection loop or Heat Trap (anti-convection valve) either factory-installed or site-supplied on both feed and outlet lines. Provide 10-year manufacturer's warranty on tank unless the approved model is not available with such a warranty.

2. *Required capacity*. The minimum first-hour rating, in gallons, shall be as follows: 1 bedroom – 43; 2 bedrooms – 60; 3 bedrooms – 70; 4 bedrooms – 80; 5 or more bedrooms – 90.

2. *Atmospherically vented, non-direct vent units*. In certain rehab construction where specifically authorized by PHDC, a conventional atmospheric HWH may be used and common-vented with the furnace. Cf. 15.6 B 2.

3. *All other units*. Unless it uses 100% outside combustion air, the unit shall be power-vented. If it does use outside combustion air (is direct-vented) the vent design may be of passive or fan-assisted type. Atmospherically vented HWH units that draw combustion air from the surrounding area are prohibited in the living space, in conjunction with central air conditioning, and in all new construction.

4. *All other units – venting options*. Depending on the building configuration, passive direct-vent units, power-vented direct-vent units, or power-vented non-direct-vent units may be used. The appropriate type of HWH depends on the proposed locations of the vent terminal and of the equipment in relation to the vent terminal. The table (next page) shows approved units and the circumstances in which each may be used.

5. When the water heater vent cap is located within 8 ft. of the ground a protective vent cap screen shall be installed to prevent anyone from touching the hot vent cap.

6. Electric HWHs will be approved *only* when the developer can show that there is no feasible alternative. They must have at least R-20 insulation and *must be off-peak metered.*

15.4 B **Indirect-Fired Domestic Hot Water:**

1. When a boiler is used for space heating, an immersed hot coil or double tank indirect-fired heat exchanger/storage tank, with heat traps as specified for HWHs, may be used instead of a HWH. The storage tank shall be valved as a separate zone with priority over space heating. Given 176 degree F boiler output, it shall be sized to provide at least 24 gallons at 140 degrees F in 10 minutes and 60 gallons in the first hour.

2. Indirect-fired water heaters shall be provided with a manufacturer's warranty of not less than 10 years.

3. Acceptable models: Amtrol WH-6, Ergomax E20, Phase III TR-30.

(Continues next page)

DOMESTIC WATER HEATERS ACCEPTED IN VARIOUS BUILDING CONFIGURATIONS

PASSIVE DIRECT-VENT WATER HEATERS

Manufacturer	Model #	Can vent up	First hour	Storage (gallons)	* Vent terminal location	* HWH location
American	DVG*(*)2-40S38-N	✓	60	40	A3	C2
	DVG*(*)2-50T42-N	✓	70	50	A3	C2
Apollo	A***40(A/B)DSLW		71	40	A2	D
	A***50(A/B)DSLW		87	50	A2	D
Bradford White	DS140S***EN-11		71	40	A1	D
	DS150S***EN-11		91	50	A1	D
Lochinvar	BFN040		65	40	A1	D
Maytag	HJ650NBDSW		87	50	A2	D
Reliance	** 40 NODS***		68	40	A2	D
	** 40 NADS***		71	40	A2	D
	** 50 NODS***(W)		77	50	A2	D
Rheem	21*30DV		51	30	A1	C
State	PR*40NODS***(W)		68	40	A2	D
	PR*50NODS***(W)		87	50	A2	D
U.S. Craftmaster	DVG2*4038SN	✓	60	40	A3	C2

* ***location/venting codes*** *are shown following the tables.*

POWER DIRECT-VENTED WATER HEATERS

Manufacturer	Model #	Can vent up	First hour	Storage (gallons)	*Vent terminal location	*Vent con-nector
A. O. Smith	FPD-40-2(34/36/50)	✓	75	40	A1	X
	FPD-50-2(34/36/50)	✓	83	50	A1	X

POWER VENTED WATER HEATERS (NON-DIRECT VENT)

Manufacturer	Model #	Can vent up	First hour	Storage (gallons)	*Vent terminal location	*Vent con-nector
A. O. Smith	FPSE-40-230E	✓	75	40	B	K
	FGSE-50-230E	✓	84	50	B	K
	FPST-50-230	✓	103	50	B	K
American	PVG*2-40T50-3N	✓	72	40	B	H
	PVG*2-50T63-3NH	✓	95	50	B	H
Apollo	A**40N(Q/R)V(E)TL2(W)	✓	81	40	B	G
	A**50N(Q/R)V(E)TL2(W)	✓	91	50	B	G
Bradford White	M-I-TW40L***N-1(2/3)	✓	72	38	B	F
	M-I-TW50L***N-1(2/3)	✓	85	48	B	F
	M-II-TW50T***N-10	✓	105	48	B	J
	M-II-TW65T***N-10	✓	129	65	B	J
GSW	40SNV		68	40	B	I
Lochinvar	DVN05(0/2)	✓	96	48	B	F
	DVN065	✓	120	65	B	J

Manufacturer	Model #	Can vent up	First hour	Storage (gallons)	*Vent terminal location	*Vent con-nector
Reliance	**40NAV(E)T(W)	✓	73	40	B	G
	40NOV*(2)(W)	✓	74	40	B	G
	**40NOVET(2)(W)	✓	81	40	B	G
	50NOV(E)T(2/W/2W)	✓	80	50	B	G
	**50NAVETW	✓	80	50	B	G
	**40NRV(E)T(****)	✓	81	40	B	G
Sears	153.335816	✓	74	40	B	G
State	PR*40NOV(E)T(***)(2)(W)	✓	74	40	B	G
	PR*50NOV(E)T(***)(2)(W)	✓	80	50	B	G
	PR*40NRV(E)T(L)(***)(2)(W)	✓	81	40	B	G
	PR*50NRV(E)T(L)(***)(2)(W)	✓	91	50	B	G
U.S. Craftmaster	PVG2*4050T3N	✓	72	40	B	L
	PVG2*5063T3NH	✓	95	50	B	L

* ***Location/venting codes (for use as guideline only; verify with manufacturer. Note that although model numbers listed have been updated, the corresponding installation instructions have not been researched anew.)***

A1 Sidewall (direct-vent): min. 9" from operable door or window; 3' above outside (non-combustion) air intake within 10' on either side; 1' above grade.

A2 Sidewall (direct-vent): min.18" from operable door or window; 3' above outside (non-combustion) air intake within 10' on either side; 1' above grade.

A3 Sidewall (direct-vent): min. 9" from operable door or window; 3' above outside (non-combustion) air intake within 10' on either side; 1' above grade. Vertical venting kit available.

B. Sidewall (not direct-vent): min. 4' below/to side of, 1' above operable door or window; otherwise same as A1.

C1 Against exterior wall at vent location, typically within 6" — no vertical adjustment.

C2 Against exterior wall at vent location, or directly under roof jack (max. 15' from base of heater).

D. Near exterior wall. Vertical and/or horizontal extension kits available.

E. Horizontal and vertical venting permitted, 40' max. vent length with one elbow, less with up to three elbows not including terminal.

F. Horizontal venting, 95' max. vent length with one elbow, less with up to four elbows not including terminal. Vertical venting, 50' max. vent length with one elbow, less with up to four elbows not including terminal.

G. Horizontal venting, 35' max. total, 20' vertical max., three elbow max. not including terminal.

H. Horizontal or vertical venting permitted. Up to 40' of vent with three "long sweep" elbows.

I. Horizontal venting only, up to 20' with two elbows, 15' with max. three elbows not including terminal.

J. Horizontal venting, 70' max. (less with up to five elbows max.); vertical venting, 70' max. (less with up to five elbows max.).

K. Horizontal venting up to 40 "equivalent feet." Vertical venting up to 35 "equivalent feet."

L. Horizontal venting only, 35' max. with 20' max. vertical rise. Three elbow max., not including terminal.

X. Horizontal, vertical and down venting up to 40 "equivalent feet."

SECTION 15.5 SPACE HEATING – GENERAL

15.5 A **Related sections:**

15.9 Ductwork
15.15 Testing, Adjusting and Balancing Conditioned Air Systems

15.5 B **Work Included –**

1. The complete new heating system, including boiler or furnace, distribution system, fuel system, temperature control system, and all required accessories.

2. Installation of the boiler/furnace on 4-inch thick solid block base.

3. All cutting in existing work required and cost of patching same.

4. Cleaning, testing, balancing, adjusting, and performance tests for all equipment and materials furnished or installed under this section.

5. New electrical wiring on dedicated circuit, including switch at top of basement stairs for oil burner and switch near heater for gas system.

6. Low voltage control wiring and electrical equipment necessary for the proper operation of the systems.

7. Final gas and water connections to equipment installed under this section.

15.14 D **References –**

"Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems," August 2000 – The Consortium for Energy Efficiency (CEE). Available as a free download from their website at www.cee1.org.

"Manual J, Residential Load Calculation" – Air Conditioning Contractors of America (ACCA), most recent edition

15.5 E **Requirements –**

Same as Article 15.2 A 2, a through d.

15.5 F **Design Data –**

1. *Equipment sizing.* Heating system shall be designed to maintain interior temperature of 70º F when exterior temperature is 10º F. The heating capacity (output) rating of the furnace or boiler shall not exceed 130% of the calculated design heat load. The furnace, boiler or combination warm air/domestic hot water system shall be the lowest-capacity approved unit in its model line whose output rating is at least equal to the design heat load. **EXCEPTION** — *non-direct-vent, non-condensing gas furnaces:* in Section 15.6, five ranges of rated output are defined; two or more approved furnaces are listed in each range. When a furnace of this type is used, it shall be (a) a model listed in the output-range category whose minimum is at least equal to the calculated design heat load, or (b) a model which is listed in the next-smaller category and whose output rating is at least equal to the design heat load. If two or more models from the chosen manufacturer meet this standard, the smaller shall be used. Design heat load shall be calculated and documented by contractor, using ACCA Manual J, the table below, or other methods expressly approved by PHDC/RDA. The table may only be used for a "typical" structure with the characteristics listed.

Characteristics assumed in table:

Wall insulated to R-13 (basement wall insulated to R-10)
Slab on grade insulated per 7.2 C 6 c (6) of these Specifications
Roof insulated to R-30
Natural air infiltration rate = 0.5 ACH
Window "u" value = 0.4
Induced ventilation air = 30 CFM.

BTUH Heating Load Estimates
for typical masonry twin/row house

Total floor area	10.02	BTUH / sq. ft.
Area under roof (footprint)	2.60	BTUH / sq. ft.
Window area	31.20	BTUH / sq. ft.
Exposed perimeter wall area including basement walls	5.85	BTUH / sq. ft.
Area of basement floor or insulated framed floor over unconditioned space	1.82	BTUH / sq. ft.
Exposed slab perimeter	21.06	BTUH / linear ft.

Contractor shall submit documentation of heating load calculations for each (type of) unit to PHDC/RDA and obtain its approval before ordering equipment.

2. *Code compliance.* Installation shall be in accordance with the City of Philadelphia fire code, NFPA 31.54 and 90B, National Fuel Gas Code and National Electrical Code.

15.5 G **Normal Space Heating System Requirement –**

1. Where a sound hydronic heat distribution system does not exist, forced warm air (FWA) is the required means of heating a living unit unless an alternative system is expressly approved by PHDC/RDA.

2. A new hot-water boiler may be installed (1) when there is a sound hot water heat distribution system; (2) when there is a sound two-pipe steam heat distribution system, which shall then be changed from steam to hydronic; or (3) in other special circumstances with the approval of PHDC/RDA.

3. *(Steam boilers in repair/partial rehab applications: see **appendix**.)*

4. When gas service is available, the furnace or boiler shall be gas-fired. *(Exception: see **appendix**.)*

15.5 H **Variance Procedure for Alternative Space Heating Systems in Special Situations –**

1. PHDC/RDA recognize that there may be unusual situations in which it is appropriate to use a heating system other than those listed in Sections 15.7 and 15.9. For example, electric resistance heat may be cost-effective for zoned backup in a superinsulated solar dwelling.

2. A developer who proposes an alternative heating system must demonstrate that operating costs of the proposed system will be affordable. Accordingly, the developer must submit results of a building energy analysis simulation (using DOE-2.1 or other approved simulation software) to show the predicted cost, at current Philadelphia energy prices, of maintaining 70° F interior temperatures throughout the heating season in a standard Philadelphia weather year.

3. PHDC/RDA will approve an alternative system for the proposed development if and only if its predicted heating cost is no higher than the Standard Heating Cost of a dwelling [or multi-unit building] of the same size. Standard Heating Cost, the estimated average cost to heat a dwelling [or multi-family building] rehabilitated to OHCD/PHDC/RDA energy efficiency requirements, is defined as:

   $$SHC = FA * .042*10^6 \text{ BTU} * X$$

   where FA is floor area of living space, and X is the current Philadelphia price per million-BTU energy equivalent of natural gas.

15.5 I **Placement of equipment –**

1. *Elevation from basement floor.* Equipment in basement shall be elevated 4 inches above floor level on a continuous masonry platform, or (if designed to be hung) may be hung from joists above.

2. *Clearance for service access.* Allow sufficient space around equipment for proper operation and servicing. Minimum clearances between equipment and adjacent walls/structures/other objects shall be:

   a. 36 inches on the side containing the service panel

   b. 12 inches on all other sides

   c. 48 inches above vertical discharge unit

   d. as specified by manufacturer or required by PGW, if greater than above.

15.5 J **Thermostatic control –**

Standard Honeywell or digital Hunter 44402 thermostat as directed by PHDC/RDA.

15.5 K **Commissioning –**

See Section 15.15. Contractor shall verifiy correct operation of space heating and, if it is a forced warm air system, shall identify all equipment on the forms cited therein.

SECTION 15.6 VENTING OF WATER HEATERS AND HOUSE HEATERS

15.6 A **Condensing Appliances:**

1. Condensing appliances shall be vented through plastic pipe in accordance with the National Fuel Gas Code and the manufacturer's instructions.

15.6 B **Non-Condensing Appliances:**

1. Non-condensing appliances vented horizontally – Water heaters (with the exceptions noted in 15.4A) shall be vented horizontally, and furnaces/boilers may be vented horizontally, through

a side or rear wall in accordance with the National Fuel Gas Code and the manufacturer's instructions.

2. Non-condensing appliances vented vertically –

   a. Where specific conditions apply, PHDC may permit the use of an approved furnace common-vented with an atmospheric water heater. Approval will be granted only for single-family rehab units (not new construction); the units may *not* be centrally air conditioned. Any such installation must comply with manufacturers' instructions for common-venting fan-assisted and atmospherically-vented appliances and with all applicable requirements of the National Fuel Gas Code (Part 7, *Venting of Equipment* and Part 11, *Sizing of Category I Venting Systems)*. In addition,
      - the combustion equipment must be in a basement;
      - the B-vent must be inside the thermal envelope;
      - the water heater vent connector must be no larger than 3" in diameter;
      - the final as-tested infiltration rate must be not less than 1400 CFM_{50};
      - a hard-wired carbon monoxide detector/alarm must be installed near the combustion equipment. The CO detector must be UL-listed and meet International Approval Services standard 6-96 (be labeled IAS-696).

   b. In other special situations OHCD/PHDC/RDA may permit the use of an approved power-vented or passive direct-vented water heater and approved furnace vented vertically. Neither may be common-vented with any other appliance; each must have a dedicated code-approved vent.

15.6 C **Appliances Located in an Equipment Room in the Living Space:**

1. Approved direct-vent appliances may be located in the living space.

2. Approved power-vented, non-direct-vent appliances (each with its own dedicated vent) may be located in the living space. The equipment room shall then have permanently open ventilation registers to admit combustion air from the living space; these shall be sized to provide the required net free area per 1,000 BTU of gas input in accordance with the National Fuel Gas Code. Combustion air shall not be drawn from a bedroom or bathroom.

3. Under no circumstances may atmospherically vented non-direct-vent appliances be installed in the living space.

15.6 D **Chimneys:**

1. Unused chimneys shall be sealed off; deteriorated portions shall be either made sound or demolished and capped.

SECTION 15.7 WARM AIR FURNACES

15.7 A **Gas-Fired Forced Warm Air Furnaces (general):**

1. New gas FWA heaters shall be either non-condensing units rated 78 to 83% AFUE, or condensing units. The *Effective annual efficiency,* as defined below, shall be not less than the minimums specified in the following table. Effective annual efficiency takes into account electrical consumption.

a. *Effective annual efficiency standard.*

Furnace category	Minimum effective annual efficiency
Non-condensing, <60 mBtuh	77.2%
Non-condensing, ≥ 60 mBtuh	78%
Condensing (all)	92%

b. *Effective annual efficiency defined.*

$$\text{Effective annual efficiency} = \frac{\text{AFUE} * 1000 * \text{Ef}}{(1000 * \text{Ef}) + (\text{Cost_ratio} * \text{Eae})}$$

where AFUE = annual fuel utilization efficiency expressed as a decimal fraction (e.g. 78% = 0.78);

Ef = estimated annual fuel energy input in million Btu;

Eae = estimated annual electrical consumption in kWh;

1000 = conversion from million Btu to kBtu;

$$\text{Cost_ratio} = \frac{(\text{Electrical_cost / kWh}) * (\text{kBtu / ccf})}{(\text{Gas_cost / ccf}) * (\text{kBtu / kWh})}$$

The ratings for AFUE, Ef and Eae shall be as published in the most recent issue of the GAMA *Consumers' Directory of Certified Efficiency Ratings*. For the tables in this section, the value of the Cost_ratio parameter was set at 4.65.

2. Heaters shall be AGA and U.L. approved and labeled and shall meet the following requirements:

   a. Air filters and filter housing shall be provided. Filter housing shall not allow house air to bypass the sealed return ducting.

   b. Ignition shall be accomplished by means of an electric spark or hot surface ignitor.

3. Gas-Fired Warm Air Furnaces (approved types) –

   a. Non-condensing units, direct vent: unit shall be a model that is AGA certified for direct venting, shall have a sealed combustion chamber, and shall be supplied with 100% outside combustion air. The only such units that currently meet the effective efficiency standard have a heating capacity of 40 mBtuh.

      Acceptable non-condensing direct vent furnaces:

      Airquest/Heil/Tempstar NTC7050BF**
      Arcoaire/Comfortmaker GNL050N12**

   b. Non-condensing units, power vented: The following table lists non-direct-vent, non-condensing upflow units, by heating capacity range, that are appropriate where PHDC/RDA have authorized venting through a B-vent. The list may not be exhaustive. Downflow and horizontal units are not shown. It is the contractor's responsibility to demonstrate that a non-listed unit meets the requirements of 15.7 A 1.

ACCEPTABLE NON-CONDENSING *UPFLOW* GAS FURNACES BY HEATING CAPACITY RANGE

as of 10/2001

Rated heating capacity shown in [square brackets]

MANUFACTURER	<45 MBTUH	45-60 MBTUH	61-75 MBTUH	76-100 MBTUH	>100 MBTUH
AMANA			GUIV090**50 [74]	GUIV115**50 [94]	GUIV140**50 [111]
AMERICAN STD. (Freedom 80 VS)		AUD060R9V3J* [48]		AUD100R9V5J* [79]	AUD140R9V5J [111]
LENNOX (Merit 80)		G60UHV-36-070(X)-** [54]	G60UHV-36-090-** [72]	G60UHV-60C-110(X)-** [90]	G60UHV-60D-135-** [108]
LENNOX (Value 80M)					80MGF4/5(X)-140*-** [112]
MILLER, NORDYNE (Miller)				G6RA120*-20 [97] G6RA120*-16 [98]	
PAMECO (Thermal Zone)				GM120K20C-S [97] GN120K20B-S [97] GM120K16B-S [98] GN120K16B-S [98]	
RHEEM	RGPL-05(E,N)BMNR [41]				RGPK-15(E/A)RJR [122]
RUUD	UGPL-05(E,N)BMNR [41]				UGPK-15(E/A)RJR [122]
SEARS (Kenmore)	NTC7050BF** [40] NTV6050FFB** [40] VNE050B12** [40]		NTV6075GF** [61] VNE075F14** [61]	NTV6100KJ** [80] VNE100J20** [80]	
SKYMARK INT'L (Skypak II)	SGAC401212* [32]				
WEATHERKING	WGPH-04EAUSR [36] WGPH-04NAUS [36] WPGL-05(E,N)B [41]				WGPK-15EARJR [122] WGPK-15NARJR [122]

c. Condensing units: Condensing furnaces shall have no warranty provision excluding chlorine environments. A copy of the warranty must be submitted with required system documentation.

The upflow condensing furnaces listed in the following table all meet the minimum effective efficiency requirements of 15.7 A 1. The list may not be exhaustive. Downflow and horizontal units are not shown. It is the contractor's responsibility to demonstrate that a non-listed unit meets the efficiency standard. In all cases, it is the contractor's responsibility to verify that the warranty has no chlorine-environment exclusion.

ELECTRICALLY EFFICIENT *UPFLOW* CONDENSING GAS FURNACES

Manufacturer	Trade Name	Model Number	Output (MBTUH)
AMANA	Amana	GUX045X30B	44
ARMSTRONG	Armstrong, Air-Ease, American Aire	G2D95AU040V12B*-***U	38
		G2D95AU060V14C*-***U	57
		G2D95AU080V(16/20)C*-***U	76
		G2D95AU100V20D*-***U	95
CARRIER	Carrier, Weathermaker	58MVP060-14-L	37
		58MVP040-14	38
		58MVP080-14-L	49
		58MVP080-20-L	49
		58MVP060-14	57
		58MVP100-20-L	61
		58MVP120-20-L	73
		58MVP080-(14/20)	75
		58MVP100-20	94
		58MVP120-20	113
INTERNATIONAL COMFORT PRODUCTS	Airquest, Heil, Tempstar (also SEARS Kenmore)	NTVM050FF***	47
		NTVM075GF***	70
		NTVM100HJ***	94
		NTVM125KN***	118
	Arcoaire, Comfortmaker (also SEARS Kenmore)	VNK050F12***	47
		VNK075F14***	70
		VNK100J16***	94
		VNK125N20***	118
LENNOX	3Dimension	G32V5-125-**	118
RHEEM / RUUD / WEATHERKING	# = R (Rheem), U (Ruud), W (Weatherking)	#GFD-09(E/N)ZCMS	86
		#GFD-12(E/N)RCMS	115

SECTION 15.8 COMBINATION WARM AIR/DOMESTIC HOT WATER SYSTEMS

15.8 A **When permitted:**

Forced-air space heating equipment using the domestic water heater as a heat source is permitted, with explicit PHDC/RDA approval, provided that the conditions below are met.

15.8 B **Water heater tank volume:**

1. Units without laundry – 40 to 50 gal. storage.

2. Units with [potential] laundry – at least 50 gal. storage.

15.8 C **Performance requirements:**

1. The system shall be a set of components sold by one manufacturer and rated for Combined Annual Efficiency (CAE) in the GAMA Consumers' Directory of Certified Efficiency Ratings ("pre-packaged system").

2. It shall be rated as follows: CAE – 0.73 or higher; Effective Space Heating Efficiency (CAafue) – 0.80 or higher; Effective Water Heating Efficiency (CAef) – 0.6 or higher.

15.8 D **Configuration and venting:**

The water heater in such installations shall meet all the requirements of 15.4 A 3. Direct-vent units are permitted. Units that draw combustion air from the surrounding area are not permitted unless power-vented.

15.8 E **Water temperature measurement:**

To verify regulation of hot water temperature, a well-type digital thermostat shall be mounted on top of the tank or on the supply pipe leaving the water heater. (This requirement does not apply to Lennox CompleteHeat system.)

15.8 F **Component reliability and maintainability:**

1. The power-vent fan, distribution air fan and circulator shall be permanently lubricated or self-lubricating.

2. The system must be installed with Teflon-coated mixing valves to protect against mineral buildup.

3. The fan coil must be equipped with a circulator that can easily be removed without cutting of any components or piping, and without draining the system.

4. A check valve must be installed between the water heater and fan coil unless the fan coil circulator includes a check valve to inhibit water flow through the heating coil when the system is not calling for heat.

5. The high point of the heating loop must be equipped with a manual air eliminator.

6. The water heater must be installed with bronze body ball valves isolating cold water supply, domestic hot water supply, and heating supply and return lines. Dielectric unions must be installed between these isolation valves and the water heater.

15.8 G **Approved systems:**

American PBG*2-34S100-2N, PBG*2-50TS100-2N (*may be any number 8 or above)
Bradford White M2CTW50T10LN-10, M2CTW75T10CN-10
Lennox CompleteHeat HM30-100.

15.8 H **Commissioning:**

The contractor shall verify that the heating coil has been completely purged of air, which compromises performance. Repeat purging may be necessary. The water heater tank temperature shall be adjusted to provide heated water capable of producing 140º F in the fan coil, but shall not be set above 145º F.

SECTION 15.9 DUCTWORK

15.9 A **References:**

"Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning – Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)

"Manual D, Residential Duct Systems" – Air Conditioning Contractors of America (ACCA) 1995 or later

15.9 B **Products:**

1. All ductwork, plenums, casings, construction and erection methods, including metal gauges, reinforcing, fittings, connections, access doors, and all other accessories shall be in accordance with Section 1 and 2 of the SMACNA Duct Manual.

2. Ductwork shall be galvanized steel of gauges noted in SMACNA manual. With prior written approval of PHDC/RDA, flex duct may be permitted for branch runs of less 8 feet serving a single register.

3. Supply registers shall be provided with volume adjustment damper.

4. Mastic sealant:

   RCD #6 Mastic
   Foster Aqua-Fas

15.9 C **Location:**

1. Within thermal boundary – Ductwork outside the thermal boundary is prohibited.

2. On exterior walls – Branch runs on exterior walls should be avoided if possible. When they are unavoidable, clearance must be provided to permit continuous un-compressed insulation on the cold side of the duct as specified in section 7.2.

15.9 D **Supply system:**

1. Configuration – Trunks and branch runs shall be as short and compact as possible. Registers on ground floor may be located low on the wall; on upper floors they shall be mounted high on the wall or in the ceiling. If windows meet the requirements of Section 8.8, registers need not be on the exterior wall or the ceiling above. They may be mounted high on the opposite (interior) wall and designed to direct airflow across ceiling and down the exterior wall.

2. System pressure drop – Not to exceed 0.2 inch w.c. per 100 equivalent feet of run.

3. Maximum velocity – 600 feet per minute.

4. Load sizing – Branch runs shall be designed to provide the airflow required by the heating and cooling load calculated for each room (Sections 15.5 F, 15.14 E). As an alternative to duct system engineered in accordance with ACCA Manual D, ducts may be sized according to the following table.

CFM	Round Duct	Rectangular Duct
0 - 65	5"	6 x 3.5
66 - 110	6"	10 x 3.5, 8 x 4, 6 x 5
111 - 160	7"	14 x 3.5, 12 x 4, 8 x 6
161 - 230	8"	18 x 3.5, 16 x 4, 10 x 6, 8 x 8
231 - 410	10"	26 x 4, 16 x 6, 12 x 8, 10 x 10
411 - 650	12"	24 x 6; 16 x 8, 12 x 10
651 - 1000	14"	32 x 6, 22 x 8, 16 x 10, 14 x 12
1001 - 1400	16"	30 x 8, 22 x 10, 18 x 12, 16 x 14

5. Duct plan must be provided. Design cfm rating for each supply register shall be indicated on plan.

15.9 E **Return system:**

1. Return registers –

   a. *One- and two-story units.* Install a single non-closing register low on the wall in a central area communicating directly with all closable rooms. In a two-story unit, register should be on the lower floor.

   b. *Three- and four-story units.* Install two non-closing return registers, one low on a ground-floor wall and one high on a top-floor wall. Both should be in a central area communicating directly with all closable rooms.

2. Ducting –

   a. Return systems should be sealed with mastic and, with the exceptions noted below, should be "hard ducted."

   b. Cavity returns (general): Joist panning is permitted where the joist cavity is exposed (e.g. unfinished basement). Seal throughout, including all joints, corners and penetrations.

c. Cavity returns (special case): Where the governing authority grants a written waiver to authorize cavity returns in other circumstances, cavities must be fully metal panned, sealed and functional for inspection before drywall is installed. After drywall is installed, pressure testing may be required to prove seal: with air handler fan running, pressure shall not be affected by more than 1 Pascal or 3 inches w.c. in framing cavities adjacent to the ducted section and in the mechanical room itself.

d. Wood framed return plenums: may be used with transfer grilles to permit air egress from closed rooms to central return (see 15.9 F). *Subject to the same sealing and testing requirements listed in "c" above*, other return plenums may also be wood-framed.

e. Filter retainer: Provide with hinged galvanized closure or install inside fan compartment.

3. Cross-section –

The net free area of each return grille and the cross sectional area of each return duct shall not be less than either (a) 90% of the cumulative cross-sectional areas of the supply ducts, or (b) 24 sq. inches for each 100 cfm of supply air.

15.9 F **Return air egress from rooms:**

1. Every room supplied with conditioned air shall be provided with a non-closable means for air egress. Comply with one of the following –

a. Prescribed area method: Provide transfer grilles or ducts which – in combination with an optional door undercut not more than 3/4" – have a minimum total cross-section at least twice the supply duct area. (Example: for a bedroom served by one 5-inch round supply duct, the Air Egress Area shall be at least 39.3 sq. inches. Maximum allowable door undercut provides 22 sq. inches.) *For bathrooms only,* with prior permission of PHDC/RDA a door grille or 1-5/8" door undercut may be used instead of the through-wall or ducted transfer grille described below.

b. Performance test: With doors closed, air handler shall not pressurize the room more than 3 Pascals (0.01 inches w.c.) relative to the area containing the main return register; air flow measured at the supply register shall not decrease by more than 10 percent. In any case, total airflow may not be less than the cfm calculated for the room and shown on the duct plan.

2. Configuration of transfer duct/grilles (required except for bathrooms) –

a. Through wall (preferred method):

i. *Prefabricated through-wall pressure relief vent with sound-absorbent baffle.* "Zenon," Tamarack Technologies, (800) 222-5932. Use 4 X 12-inch model for rooms with a single 5-inch round or 3.5 X 6-inch rectangular duct. Use 4 X 24-inch model for rooms with duct cross-sectional area up to 48 sq. inches.

ii. *Site-built – offset grilles connected through wall.* Utilize wood stud cavity, or box in steel framing with wood 2x lumber. Use sealed 2x blocking or batt-in-plastic bag pillow to block off remainder of stud cavity within 6 inches of grille openings. Offset room- and hallway-side grilles by 2 to 3 feet between openings and seal to drywall. Sealant must be visible to inspector upon removal of grille. Where wall configuration does not permit offset as described, place grilles above door with fixed uni-directional vanes oriented upward to minimize light transmission.

b. Ducted: For other than through-wall above, use galvanized steel. Do not run in exterior walls or outside thermal boundary.

15.9 G **Execution:**

1. Industry standard – Installation of all ductwork shall conform to NFPA 90-B.

2. Supply balancing dampers – Install balancing dampers near takeoff in all accessible supply runs. Dampers are not required in engineered systems.

3. Return damper in air-conditioned, three- and four-story units – Provide (labeled) damper to switch between upper and lower return. Label shall indicate "Position for air conditioning" (lower return closed) and "Position for heating" (upper return closed).

4. Exposed ducts – Exposed ducts are permitted in basement/furnace room only. Other ductwork shall be concealed.

5. Screwed joints – Secure tight fitting joints in steel ducting with two screws spaced 120 degrees apart. Provide additional screws to eliminate possibility of damage to seal by joint movement before close-in.

6. Sealing of ductwork –

   a. Where required – Seal supply and return ductwork with mastic at all joints and gaps, including joist panning, plenum connections, and register boots.

   b. Joint reinforcement – Embed fiberglass mesh tape in mastic if joint rotation is possible or joint opening exceeds 1/8 inch.

7. Combustion air transfer grilles – Install as required by National Fuel Gas Code.

8. For system with air conditioning, insulate all ducts with 1-1/2 in. foil-faced fiberglass duct insulation.

15.9 H **Commissioning:**

After construction, HVAC installer or third-party air balancer must balance the system and verify that air flow (in cooling mode, if applicable) at each outlet register equals the planned flow plus or minus no more than 10 percent. Each unit must be balanced, with balancing report provided on RDA/PHDC approved form in accordance with the instructions in Sect. 15.15.

SECTION 15.10 HOT-WATER BOILERS

15.10 A **Gas-Fired Hot-Water Boilers:**

1. Boiler shall be direct-vent, cast iron package boiler, with insulated steel jacket, designated for forced hot water heating.

   (see 15.10 C, HIP appendix, for non-direct-vent boilers approved in certain repair and partial-rehab programs). It shall be IBR rated and U.L. approved and labeled and shall be rated at least 82% AFUE (per GAMA directory).

2. Approved models –

   Weil-McLain GV Series
   Hydrotherm Hydro-Pulse series

15.10 B **Auxiliary boiler components:**

1. Circulator – The pump capacity shall be selected for the total head and gpm required by the system and be within 30% of the pump curve, the motor horsepower shall be non-overloading at any point on the pump curve and be not more than 1750 rpm.

2. Expansion Tank – The expansion tank shall be ASME approved bladder type, equipped with tank airtrol fitting and drain and air discharge valve. The tank shall be sized as follows:

   Up to 125 MBH – 15 gallon tank
   125 to 175 MBH – 18 gallon tank
   176 to 200 MBH – 24 gallon tank
   201 to 250 MBH – 30 gallon tank

3. Air Vent – An automatic air vent and air scoop shall be provided at a high point in the main supply piping.

4. Water Feed – An automatic water feed, capable of filling the system to its maximum height, shall be installed in parallel to the manual feed and provided with separate stop valve on discharge (boiler) side.

SECTION 15.11 HYDRONIC HEAT DISTRIBUTION SYSTEMS

15.11 A **Heating water piping system:**

1. Heating water piping shall be copper tubing, hard drawn type “L” with wrought copper fittings conforming to ASTM B88.

2. All soldering shall be done with 95/5 lead-free solder and all piping shall be cleaned and cut ends reamed.

3. Provide brass ball shut-off valves as required to assure proper shut down of components of all systems for easy removal and/or maintenance without draining system. Valves shall be provided at boiler, pump and main runouts and returns to heating system.

4. Insulation – All hot water heating piping installed in unheated spaces other than basements shall be completely insulated with 5/8-inch thick closed-cell polyethylene foam. All fittings (ells, tees, and valves) shall be wrapped and taped with foil tape. All joints shall be sealed and taped.

15.11 B **Radiation:**

1. Furnish and install new baseboard fin-tube radiation through structure, sized for heat loss of each room.

2. Baseboard shall be IBR rated, similar to Trane B7-3 with 3/4 inch copper tubing, 1-1/2 x 2-1/4 inch aluminum element, 640 BTUH per foot at 190º F average water temperature. Flow rate shall be based on 20º F temperature drop. Provide all fittings and accessories required for complete installation. Provide a manual air vent on all sections.

SECTION 15.14 CENTRAL AIR CONDITIONING

15.14 A **Related sections:**

15.9 Ductwork
15.15 Testing, Adjusting and Balancing Conditioned Air Systems

15.14 B **Work included:**

1. A complete new central air conditioning system, including condensing unit and pad, cased coil with factory equipped thermal expansion valve (TXV), means of gravity or pumped condensate removal, heating-cooling thermostat, electric service and disconnect for condensing unit, low- and line-voltage wiring, refrigeration lines and insulation.

2. All required cutting of existing work and cost of patching same.

3. Cleaning, evacuating, charging, balancing and testing of all equipment and material furnished or installed under this section.

4. Certification of subcooling test and amount of refrigerant added or subtracted from system for each unit.

15.14 C **References:**

"Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems," August 2000 – The Consortium for Energy Efficiency (CEE). Available as a free download from their website at www.cee1.org.

"Manual J, Residential Load Calculation" – Air Conditioning Contractors of America (ACCA), most recent edition

"Manual D, Residential Duct Systems" – ACCA, 1995 or later

Directory of Certified Unitary Equipment Standards, Air Conditioning and Refrigeration Institute (ARI), most recent edition.

15.14 D **Requirements:**

Same as Article 15.2 A, a through c.

15.14 E **Design Data:**

1. *Cooling capacity.* Cooling system shall be designed to maintain interior temperature of 75° F when the exterior temperature is 95° F. The cooling capacity shall be 115% of the calculated

design cooling load. Load calculations must be per ACCA Manual J or approved alternate method. Cooling load (and blower capacity) may be derived from the following table, provided that the structure is a "typical" masonry row or twin dwelling with the thermal characteristics listed. For structures with different characteristics, room cooling loads must be calculated using Manual J.

Characteristics assumed in table:

Wall insulated to R-13

Roof insulated to R-30

Natural air infiltration rate = 0.5 ACH

Window "u" value = 0.4 and SHGC = 0.55

Induced ventilation air = 30 CFM.

The total cooling load is the sum of the floor-area and window-area loads for each room.

CFM and BTU Cooling Load Estimates
for typical masonry twin/row house

	BTUH/Sq. Ft.	CFM/Sq. Ft.
Floor area (irrespective of windows)	13.81	0.55
Window area		
West exposure	54.00	2.16
Northwest exposure	39.30	1.57
North exposure	23.00	0.92
Northeast exposure	38.00	1.52
East exposure	54.00	2.16
Southeast exposure	49.00	1.96
South exposure	34.00	1.36
Southwest exposure	49.00	1.96

Contractor shall submit documentation of cooling load calculations for each type of unit to PHDC/RDA and obtain its approval before starting installation.

2. *Equipment sizing.* The condenser/coil combination shall be the **lowest** capacity unit in its model line whose output meets this requirement (see chart). Most units will call for 1½-ton systems. **Oversized systems will not be accepted**. Load calculations must be per ACCA Manual J or, if applicable, the simplified method above. *Contractor shall submit documentation of cooling load calculations for each type of unit to PHDC/RDA and obtain its approval before beginning installation.*

   The chart below will assist in determining the proper size of central air conditioner for a given installation. To use the chart, first determine the Manual J peak load in tons (i.e., divide the peak load in Btus/hr by 12,000 Btus/hr to get the equivalent tons) and look up that load in the

first column. The second column, which adds a 15% oversize factor, indicates the largest theoretically appropriate unit. The third column, with capacity in half-ton increments, shows the size of commercially available unit to be specified in each case.

Central air conditioning equipment selection

Manual J peak load (tons)	Manual J with 15% oversizing (tons)	Contractor equipment selection (tons)
1	1.15	1.5
1.1	1.27	1.5
1.2	1.38	1.5
1.3	1.50	1.5
1.4	1.61	1.5
1.5	1.73	2
1.6	1.84	2
1.7	1.96	2
1.8	2.07	2
1.9	2.19	2.5
2	2.30	2.5
2.1	2.42	2.5
2.2	2.53	2.5
2.3	2.65	2.5
2.4	2.76	3
2.5	2.88	3
2.6	2.99	3
2.7	3.11	3
2.8	3.22	3.5
2.9	3.34	3.5
3	3.45	3.5

3. *Duct sizing.* Ducts, supply registers and return grilles shall be sized and selected with the use of ACCA Manual D or of the duct-size table in 15.9 D above. Sizing must be based on cooling-load estimates for each individual room.

15.14 F **Equipment:**

1. The efficiency of the system, as listed in the latest ARI *Directory of Certified Unitary Equipment Standards,* shall be SEER = 12.0 or higher.

2. The installed evaporator coil must be verified to be a rated match with the condenser coil, as listed in the ARI *Directory.*

3. All equipment must be properly tagged and easily identified by make and model number.

4. Condensing unit shall be an air-cooled type with compressor and condenser in weathertight cabinet designed for installation outside building. Compressor shall be hermetic, furnished with suction and liquid service valves. Condenser shall have copper tube, aluminum fin coil with sub-cooling surface. Condenser fans shall be quiet-operating. Casing shall be 20-gauge galvanized, bonderized steel with baked enamel finish. Unit shall have a warranty of at least five years on compressor and coil, one year on all other parts.

5. Coil shall be factory-cased coil with factory-equipped thermal expansion valve (TXV). **Fixed-orifice equipment will not be accepted.**

6. Supply plenum shall be galvanized sheet metal.

7. Condensate pump shall be rated for use with the condensate of high efficiency gas furnaces and air conditioning units, and of sufficient head capacity for application. "Little Giant VCM-15ULS", "Beckett CU14-1UL" or equivalent.

8. PVC piping shall be solvent-weld type. All ends shall be square and reamed.

9. Condenser pad shall be plastic, made for this application, sized per manufacturer's recommendations and at least 2 inches high. In no case shall its depth or width be less than that of the condensing unit.

10. The furnace blower shall be of sufficient rated capacity to meet the cooling requirements **but no larger**. Furnaces with oversized blowers will not be accepted.

11. Insulation for suction lines shall be 3/8-inch minimum wall thickness of closed-cell elastomeric material: "Armaflex" or equivalent.

15.14 G **Execution:**

1. Allow sufficient space around outdoor units for proper operation and servicing. Minimum clearances between equipment and adjacent structures, walls or other objects shall be 36 inches on the service panel side, 12 inches on all other sides, 48 inches above vertical discharge and in all cases as specified by manufacturer and local codes. No shrubs or trees shall be planted within three feet.

2. Coil shall be placed directly on supply side of furnace and the connection between them made airtight, typically using appropriate sealant i.e. duct mastic or equivalent. Provide means for gravity or pumped removal of condensate to wastewater plumbing, using traps where required.

3. Remove identifying label from coil and attach it to the ductwork nearby in a clearly visible location.

4. Provide access door for inspecting thermostatic expansion valve.

5. Liquid and suction lines shall be "ACR" copper of proper size per manufacturer's instructions. Suction lines shall be insulated in their full length; liquid lines shall not be insulated. Insulation exposed to weather shall have a waterproof covering providing protection from UV light and weather damage.

6. Horizontal runs should not exceed 50 feet and vertical runs should not exceed 20 feet. When it is necessary to exceed these limits, manufacturer's recommendations (e.g. for traps required to prevent loss of compressor lubrication) must be followed.

7. Code-compliant electric service and disconnect shall be provided for each condensing unit.

8. All equipment literature, including installation instructions, shall be placed in plastic storage pockets affixed to the equipment.

SECTION 15.15 TESTING, ADJUSTING AND BALANCING CONDITIONED AIR SYSTEMS

15.15 A **General:**

1. Section includes –
   a. Submittals
   b. Testing, adjustment, and balancing of ducted air system
   c. Testing and verification of air conditioning system airflow and refrigerant charge.
2. Applicability – All units with ducted air distribution systems.
3. Qualified testers – testing contractor shall be a company experienced in the adjusting and balancing of air distribution systems and commissioning of air conditioning equipment.
4. Related sections –

   7.12 C (3) Duct System Exterior Leakage Test
   15.7 Warm Air Furnaces
   15.9 Ductwork
   15.14 Central Air Conditioning

15.15 B **Submittals:**

1. Required information –
   a. Upon completion of work, submit required testing, adjusting and balancing reports to PHDC/RDA in specified format, with identifying label on cover. Each report shall be signed by the technician(s) who performed the test. The reports are (1) certified proof that

the systems have been tested, adjusted and balanced in accordance with the referenced standards; (2) an accurate representation of how the systems have been installed and are operating; and (3) an accurate record of all final quantities measured to establish normal operating values of the systems.

b. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations. If information is incomplete or further testing, adjusting and balancing is deemed necessary, submit final complete report after those further steps have been taken.

2. Format –

a. Bind report forms in letter sized folder, or three-ring binder, or portfolio binders. Label on front cover shall include the title *Duct Balancing / AC Commissioning Report* and the name and address of the property.

b. Title Page:

Testing company name, address and telephone number
Name, signature, and registration number of each technician performing test
Property name and location
Project Architect
Project Contractor
PHDC/RDA Inspector
Date of report
Balancing method used (e.g. Duct Blaster, Static Pressure, Flow Hood)
Airflow test method (Static Pressure or Temperature Split)
Refrigerant charge adjustment method (Subcooling test or Weigh-in)

c. Instrument List:

Type of instrument
Manufacturer
Model
Range

d. Fully completed City of Philadelphia "Furnace/Air Conditioning Air Balancing Report" form, including:

System Description showing manufacturer, model number, serial number and installation dates for air handler/furnace and for outside condensing unit.

Distribution Type, Duct Type, and Duct Locations for supply and return ducts.

Balancing Report indicating supply and return grille locations, design cfm and actual cfm reading for each location, a description of the adjustments made (if any), and the method used to measure cfm.

If balancing could not be achieved, an explanation of the reason and recommendations for correcting deficiencies. The report should indicate whether required modifications are within the scope of the contract, design-related; or installation-related.

The following required information –

Name and address of development

Name of General Contractor

Name of and phone number of company employing the technician(s) who performed the balancing

Name(s) of technician(s) who performed the balancing (on each form), and certification of results by same

Dates balancing was performed (on each form)

All supply and return air outlet cfm readings. Include velocity measurements where applicable. Include initial and final readings at each location.

e. Fully completed City of Philadelphia "Air Conditioning Commissioning Report" form (if applicable), including:

System Description showing manufacturer, model number, serial number and installation dates for Air Handler/Evaporator and for outside condensing units.

System Airflow Requirements, including Manufacturer, Model Number of AC and Air Handler/Furnace unit, Rated Capacity, Load calculations (from Manual J or table in 15.14 E above), Targeted System Airflow at 450 cfm per ton (as determined by load calculations), Estimated System Airflow per manufacturer's data in cooling and heating modes, difference between targeted and estimated airflow.

Verification of proper airflow, using Static Pressure method or Temperature Split method.

System Charging Verification Test, using Subcooling method (if ambient temperature is above manufacturer-specified minimum), otherwise Weigh-in method.

The following required information –

Name and address of development

Name of General Contractor

Name and phone number of company employing the technician(s)who commissioned the system

Name(s) of technician(s) commissioning the system (on each form) and certification of results by same.

15.15 C **Testing, adjustment, and balancing of ducted air system:**

1. Examination –

a. Before commencing work, verify that systems are complete and operable. Ensure the following:

Equipment is operable and in a safe and normal condition.

Temperature control systems are installed complete and operable.

Proper thermal overload protection is in place for electrical equipment.

Final filters are clean and in place (if required, install temporary media in addition to final filters).

Duct systems are clean of debris.

Fan rotation is correct.

Fire and volume dampers are in place and open.

Coil fins have been cleaned and combed.

Access doors are closed and duct end caps are in place

Air outlets are installed and connected.

Duct system leakage has been minimized.

b. Report any defects or deficiencies noted during performance of services to Architect/Engineer and to PHDC/RDA.

c. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

d. If, for design reasons, system cannot be properly balanced, report as soon as observed. Beginning of work means acceptance of existing conditions.

2. Preparation –

Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing. Provide additional balancing devices as required.

3. Air system balancing procedure –

a. Test system with blower in Cooling or "Fan ON" mode.

b. Measure air quantities at air inlets and outlets. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct, adjusting for effective grille area as provided by grille manufacturer. If data for effective grille area are not available, use a factor of 0.7 when calculating CFM.

c. Adjust air handling and distribution systems to provide uniform space temperatures free from objectionable drafts and noise. Supply and return air quantities shall be adjusted within the following tolerances: cfm flows at supply registers must equal the flows shown on design documents ± 5 percent, and cfm flows at return registers must equal the flows shown on design documents ± 10 percent.

d. Effect volume control by inside-duct devices, such as dampers. Use volume control devices to regulate branch air quantities only to extent that adjustments do not create objectionable air motion or sound levels.

b. After adjustment, take measurements to verify that balance has not been disrupted or that such disruption has been rectified.

e. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

4. Recording –

a. Recorded data shall represent actually measured or observed condition.

b. Record results on *Furnace/AC Air Balancing Report* form.

c. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

5. Final steps –

   a. Permanently mark settings of dampers and other adjustment devices, allowing settings to be restored. Set and lock stops.

   b. Leave systems in proper working order, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

   c. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by PHDC/RDA.

15.15 D **Air Conditioning System Commissioning *Step 1* – Verification of Airflow through Indoor Coil:**

1. General –

   Measured airflow over the indoor coil should be (a) as indicated in the manufacturer's installation literature, or (b) the equivalent of 400 to 450 cfm per ton for a wet coil (condensation on coil) or 425 to 475 cfm per ton for a dry coil. "Targeted Airflow" on the Commissioning Report form is defined as 450 cfm per ton. Indoor coil airflow must always be measured after any duct and plenum sealing has been completed.

2. Examination – same as 15.15 C (1)

3. Preparation – same as 15.15 C (2)

4. Test methods

   a. Static Pressure

   b. Temperature Split

5. Choice of method –

   The Air Conditioner Commissioning Report form assumes use of the Static Pressure method. This default test is unreliable, however, unless ducts near the air handler are fairly straight. If there are sharp bends or dead ends in the duct work, it is recommended that the Temperature Split method be used to verify that the system is producing proper air flow across the coil. A supplemental form is available for recording Temperature Split method results.

6. Static Pressure method –

   a. Required equipment:

      Digital or analog manometer

      Static pressure probe or pitot tube

      Drill and bits

      Screw or nut drivers

   b. Procedure:

      i. Using drill, make hole to gain access to both sides of the coil and air handler. Attach static pressure probes to tubes leading to the ports on the manometer. For analog manometers, attach the high side port to the probe inserted downstream of the coil or

air handler. Consult manufacturer's literature for a table relating static pressure difference to airflow. Find airflow for the static pressure measured above.

ii. If estimated airflow is less than the minimum flow specified in the manufacturer's installation literature (or 400 cfm per ton [wet coil] / 425 cfm per ton [dry coil]), installer must increase flow by eliminating restrictions in the duct system, increasing blower speed, or opening registers. After adjustment, re-measure.

iii. On Air Conditioning Commissioning Report form, record adjustments made, final results, and – if target airflow could not be achieved – why not.

7. Temperature Split method –

a. Background:

With this method, the air temperature drop across the cooling coil is compared to a reference value read from a table. This drop is called the "temperature split." The *Actual Temperature Split* is the difference between the drybulb temperature in the return (entering the evaporator) and the drybulb temperature in the supply (leaving the evaporator).

The *Target Temperature Split* depends on return air wet-bulb temperature and return air dry-bulb temperature.

a. Instrumentation:

Digital thermometer with thermocouple compatibility (type K and J) and Celsius or Fahrenheit readout;

Accuracy: ±(0.1% of reading + 1.3º F),
Resolution: 0.2º F to 1.0º F.

Thermocouples: five heavy-duty beaded low-mass wire thermocouples and one cotton wick for measuring web-bulb temperatures.

Standard multipoint refrigerant manifold gauge set.

b. Procedure:

This procedure may be used only when the outdoor temperature is 55˚ F or higher. The HVAC system must first be installed and charged in accordance with the manufacturer's specifications.

i. Calculate the Actual Temperature Split as the return air dry-bulb temperature minus the supply air dry-bulb temperature. Actual Temperature Split = ($T_{return, db}$) - ($T_{supply, db}$)

ii. Determine the Target Temperature Split from the table on the back of the supplemental form, using the return air wet-bulb temperature ($T_{return, wb}$) and return air dry-bulb temperature ($T_{return, db}$).

iii. Calculate the difference between target and actual temperature split (Actual Temperature Split minus Target Temperature Split).

If the difference is within plus 3˚F and minus 3˚F, then airflow is adequate.

If the difference is greater than plus 3˚F, then airflow is insufficient; installer

must increase flow by eliminating restrictions in the duct system, increasing blower speed, or opening registers. After corrective measures are taken, repeat measurement procedure as often as necessary to establish adequate airflow range. Allow system to stabilize for 15 minutes before repeating measurement procedure.

If the difference is between minus 3˚F and minus 25˚F, repeat the measurement procedure – making sure that temperatures are measured at the center of the airflow.

If the re-measured difference is between plus 3˚F and minus 3˚F, system airflow is acceptable. If the re-measured difference is between minus 3˚F and minus 25˚F, the system passes – but it is likely that capacity is low (it is also possible, though unlikely, that airflow is higher than average).

iv. On Air Conditioning Commissioning Report form, record adjustments made, final results, and – if target airflow could not be achieved – why not.

15.15 E **Air Conditioning System Commissioning *Step 2* – Verification of Refrigerant Charge**

1. Examination – same as 15.15 C (1)

2. Preparation – same as 15.15 C (2)

3. Test methods –

   a. Subcooling method

   b. Weigh-in method

4. Choice of method –

   Although the Subcooling method provides the most accurate verification of refrigerant charge in a TXV-equipped system, at ambient temperatures below a manufacturer-specified minimum (typically 75° - 80° F) it requires calibrated partial blocking of the condenser's airflow to simulate design temperatures. Accordingly, the Weigh-in method is approved for use in cooler weather. The Weigh-in method assumes that the compressor unit has been delivered with the correct factory charge and adjusts refrigerant quantity by formula to account for variations in the line length between the compressor unit and indoor coil.

5. Subcooling method –

   a. Background:

      Subcooling is the the heat removed from the refrigerant after it has changed to a liquid. Modern condensing units are designed to obtain their capacities and efficiencies at a at a given subcooling value. Any variance from the design subcooling will reduce capacity and efficiency. *Note that the "evaporator superheat" method is accurate only for capillary coils and those having a fixed orifice; it may not be used with PHDC/RDA approved systems.*

   b. Instrumentation and equipment:

      Refrigerant manifold gauge set

Contact digital thermometer, accurate to tolerances specified in 15.5 D 7 (a), with auxiliary devices as needed to establish good contact for the thermometer probe

DOT-approved recovery cylinder.

c. Setup:

i. Before the test is performed, proper airflow across the coil must be verified by static-pressure or temperature-split method.

ii. Air conditioner should be running for 10 minutes prior to the test.

d. Procedure:

i. Test must be performed when outside temperature is above minimum set by manufacturer (or, absent such guidelines, 80° F).

ii. Follow the manufacturer's guidelines for the test. *If they are not available,* follow the instructions below.

iii. Measure the compressor discharge pressure. Convert this pressure to the condensing temperature, using temperature-pressure table for the system's refrigerant. Or, simply measure the surface temperature of a protruding loop of tubing in the center of the condenser between that section's inlet and outlet.

iv. Measure the temperature of the liquid refrigerant leaving the condenser.

v. Subtract the liquid-refrigerant temperature (iv) from the condensing temperature (iii). This is the subcooling temperature.

vi. Find the correct subcooling temperature from the permanent sticker inside the condenser unit, from manufacturer's literature or from a manufacturer's slide rule.

vii. Add refrigerant if the measured subcooling temperature is lower than recommended. Subtract refrigerant if the subcooling temperature is higher than recommended. Refrigerant must be removed into an empty DOT-approved recovery cylinder or one containing the same refrigerant being removed.

viii. Allow the system to run for 10 minutes to adjust to the new operating conditions. Repeat the test until the results match the manufacturer's recommendations.

e. Recording:

Record the results of this test on *Furnace/Air Conditioning Commissioning Report – Subcooling Attachment* form. Each unit must be tested and reported.

6. Weigh-in Method –

a. Instrumentation and equipment:

Electronic scale for accurate measurement of refrigerant added or removed

Tape measure

Vernier caliper

Refrigerant of the type used in the system to be adjusted

DOT-approved recovery cylinder.

b. Procedure:

i. All lengths and quantities mentioned below are to be recorded on *Furnace/Air Conditioning Commissioning Report* form.

ii. Measure and record total feet of line set at site (one way) between compressor unit and indoor coil.

iii. Record length of line set included with factory charge.

iv. Record difference, (ii) - (iii). This is the *Line Set Adjustment.*

v. Measure the outside diameters of suction and liquid lines. Circle the appropriate row in Charging Data table on reverse of form. Record the *Rated Line Set Charge* in ounces per foot.

vi. Multiply the line set adjustment (iv) by the rated line set charge (v). Record the resulting *Charge Adjustment.*

vii. If the charge adjustment is negative, remove the indicated quantity of refrigerant to the recovery cylinder. If it is positive, add the indicated quantity of refrigerant to the unit.

SECTION 15.16 EXHAUST VENTILATION SYSTEMS

15.16 A **General:**

1. Install exhaust systems in accordance with NFPA 90-B and with duct requirements specified below –

   a. Ducted kitchen range hood.

   b. Duct for owner-installed clothes dryer.

   c. Continuous whole-house ventilation system vented from the bathroom.

15.16 B **Kitchens:**

1. All kitchens shall be provided with a range hood rated for 180 cfm minimum and ducted to exit directly through appropriate vent cap on roof or exterior wall with a minimum number of elbows. Range hood shall have a loudness rating not more than 4.5 sones in the configuration to be used. Ductwork shall be PVC Schedule 40 plastic pipe or smooth metal.

   Acceptable models –

   Broan QT2**** – 200 cfm (vertical duct configuration only)

   Broan QS1**** – 200 cfm

   Broan QS2**** – 250 cfm

15.16 C **Dryer vent:**

1. Near required 20-amp receptacle in basement or laundry area, provide 4-inch diameter rigid steel vent for clothes dryer, ducted to outside with metal anti-draft cap.

15.16 C **Bathroom/House Ventilation Fan:**

1. Fan shall be single speed, with a permanent split capacitor motor, and be rated by the Home Ventilating Institute at 1.5 sone or less. Capacity shall be according to number of bedrooms in unit: 1 to 3 bedrooms – 50 cfm; 4 bedrooms – 90 cfm; 5 or more bedrooms – 110 cfm.

   Acceptable models –

   Panasonic FV-05VQ – 50 cfm
   Panasonic FV-08VQ – 90 cfm
   Panasonic FV-11VQ – 110 cfm

2. Fan shall be mounted in bathroom ceiling.

3. Controls: fan shall be controlled (1) by the bathroom light switch (or adjacent crank timer) and (2) by a clearly labeled switch mounted in basement or furnace room, near furnace safety switch. *Off* position of basement switch shall be marked "SUMMER ONLY." When basement switch is *on*, fan shall run continuously. When basement switch is *off*, fan shall run only when bathroom light (or crank timer) is on.

4. Ductwork shall be PVC Schedule 40 DVW plastic pipe, 5-inch diameter for FV-05VQ and 6-inch diameter for other models, securely fastened together and cemented in place according to manufacturer's instructions, and shall be installed to exit directly through appropriate vent cap on roof or exterior wall with a minimum number of elbows. Horizontal runs in unheated spaces shall slope toward discharge and be sealed to wall cap with a watertight joint.

   Fan may be attached to PVC pipe with flexible vent hose, 5-inch or 6-inch diameter as above and not exceeding 2 ft. in length, using worm screw clamps and appropriate PVC reducing coupling. If located outside thermal envelope, flexible duct shall be insulated.