CONVENTIONAL HVAC SYSTEMS

This Week's Presentation

> Review: *Worksheet #7*
> *Designing for Heating and Cooling*

> **MEEB:** CHAPTER 9
> HVAC FOR SMALLER BUILDINGS

> ~~**MEEB:**~~ Typical Conditions and Nomenclature

> Worksheet #9 (We're omitting #8)

> This Week's Media Material: *Green for All*

> Case Study: *Hampden Hills Apartment*
> Conventional HVAC

Last Week: **Designing for Heating and Cooling** (Chapter 8)

Worksheet #7

… 1. Daylight factor (DF) is best defined as:

(a) the ratio of daylight intensity between the brightest and dimmest points in a building

(b) the ratio of daylight intensity between summer and winter design conditions

(c) the average daylight intensity at a specified point between 10 am and 4 pm

(d) the ratio of daylight intensity between an interior point and an exterior reference point

Last Week: **Designing for Heating and Cooling** (Chapter 8)

Worksheet #7

... 2. Which (one or more) of the following ratios are actually reasonably important to appropriate performance of the noted system:

(a) cross ventilation: the ratio of inlet opening area to outlet opening area

(b) direct gain solar heating: the ratio of building heat loss to area of solar collector

(c) daylighting: the ratio of window area to orientation (expressed in degrees from North)

(d) conventional cooling: the ratio of sensible heat gain to latent heat gain

Last Week: **Designing for Heating and Cooling** (Chapter 8)

Worksheet #7

... 3. Solar savings fraction (SSF) is best defined as:

(a) the estimated savings in fuel costs of a passive versus conventional heating system

(b) the annual purchased energy saved by a passive heating system compared to a building heated by a conventional heating system

(c) the percentage of annual heating load that is provided by a passive heating system

(d) the incremental reduction in construction cost attributed to use of a passive heating system instead of a conventional heating system

Last Week: **Designing for Heating and Cooling** (Chapter 8)

Worksheet #7

... 4. The primary difference between sensible and latent heat is:

(a) sensible heat affects dry-bulb temperature, while latent heat affects moisture content

(b) sensible heat occurs in winter and latent heat occurs in summer

(c) sensible heat can be handled by building systems, while latent heat can not

(d) sensible heat will flow within a building, while latent heat is stationary

Last Week: **Designing for Heating and Cooling** (Chapter 8)

Worksheet #7

... 5. A "phase-change" material would normally be used to:

(a) filter air in a conventional cooling system

(b) provide transparent insulation for a passive heating system

(c) ensure evaporative cooling in a cooltower system

(d) store heat in a passive cooling or heating system

Last Week: **Designing for Heating and Cooling** (Chapter 8)

Worksheet #7

... 6. Draw four simple schematic diagrams that illustrate the following passive cooling system concepts:

(a) stack ventilation

(b) roof pond

(c) earth tube

(d) cooltower

This week... <u>HVAC for Smaller Buildings</u>

MEEB: The Need for Mechanical Equipment... Why?

> *Well, what does H * V * A * C mean?*

	Heating	(Because it's *cold*)
	Ventilation	(Because we've closed the windows)
&	**A**ir	(Because that's our species' medium)
	Conditioning	(Because air is not just heated or cooled, but also treated for humidity & purity)

We need HVAC because it's too hot or too cold outside, but we like it... *just right...* inside.

But keep in mind: *Our species survived for 99,900 years <u>without</u> HVAC...*

This week... HVAC for Smaller Buildings

MEEB: Designing HVAC Equipment -- Typical Process

> Preliminary Design Phase, including the itemization of

... Activity comfort needs
... Activity schedule
... Site energy resources
... Climate design strategies
... Building form alternatives
... Considerations of passive and active systems
... System capacity is sized by general guidelines.

This week... HVAC for Smaller Buildings

MEEB: Designing HVAC Equipment -- Typical Process

> Design Development Phase, during which the following may occur:

Establish Design Conditions
Determine HVAC zones
Estimate Thermal Loads on each Zone;
Select the HVAC system.
Identify Components and Locations
Size the Components
Lay out the System

Afterwhich, the team will coordinate other systems to "finalize the design."

This week... HVAC for Smaller Buildings

MEEB: Designing HVAC Equipment -- Typical Process

> *Several of these steps are worth thinking about in detail:*

Determine HVAC zones...
by Activity, by Schedule, by Orientation, and by Internal Heat Gain.

Estimate Thermal Loads on each Zone...
for worst winter condition, for worst summer condition, for average conditions reflecting the typical environment, and for defining an annual energy consumption.

Select the HVAC system...
based on the most appropriate technical consideration for each or several zones.

This week... <u>HVAC for Smaller Buildings</u>

MEEB: Designing HVAC Equipment -- Typical Process

> *Several of these steps are worth thinking about in detail:*

Identify Components and Locations...
such as mechanical rooms, distribution trees, and in-space components, such as grilles, window units, etc.

Lay out the System...
to anticipate requirements of or conflicts with other systems, such as structure, plumbing, electrical, fire safety, and finishes.
<u>Sections as well as plans must be studied to assure sufficient clearances and head-height for both systems and occupants!</u>

This week... HVAC for Smaller Buildings

MEEB: Equipment Location and Distribution

> Central or Local?

Locally-placed HVAC equipment has the advantage of increased sensitivity to particular environmental conditions and to particular occupants' behaviors. In addition, this equipment is smaller in scale and does not affect other areas in case of failure.

Centrally-located HVAC is advantage for its being contained in a single, controllable location for maintanence and service.

In any cases, a single HVAC system might have aspects of both spatial approaches, as we shall see.

This week... HVAC for Smaller Buildings

MEEB: Equipment Location and Distribution

> Distribution "Tree" *('Cause it has a trunk and branches...)*

A centrally-located system will require a distribution tree to carry treated air to its point of service, and to return used are from those areas. Parallel, supporting systems, such as piping for coolant or water, may also reflect the topology of a tree.

The distribution channels are BIG as they leave the central plant and diminish as they "drop off" services to the furthest most point. The spatial impact on the occupied spaces as these systems travel from the central plant is usually significant, affecting ceiling height in many places.

This week... HVAC for Smaller Buildings

MEEB: Equipment Controls (Smaller Building Systems)

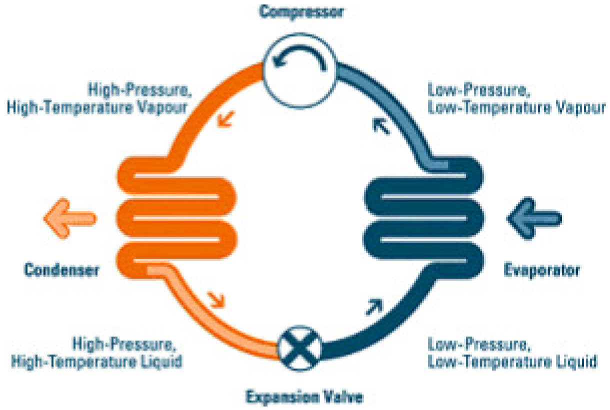
Most typically, a thermostat contols the HVAC system. A thermostat measures (drybulb) temperature, and turns the HVAC on or off to keep the temperature above (or below) the set mark.

Greater proliferation of low-voltage control systems, and more economically available control mechanisms for points along the distribution tree, have seen a transformation of the "thermostat" towards a more sophisticated, interactive "brain" which conserves energy use by measuring and modeling both human and environmental behavior. Even within a single-zone system, intelligent control of dampers and fans can increase climate control without additional consumption of power.

This week... HVAC for Smaller Buildings

MEEB: Refrigeration Cycles... Huh?
(Ok, making things colder.)

> *Compressive Refrigeration*
> **Condenser, Expansion Valve, Evaporator, Compressor**
>
> (Uh, oh, these refrigerants are mad of some nasty stuff!)



> *Absorption Refrigeration*
> **Generator, Evaporator, Compressor, Absorber**
>
> Uses those salts that were mentioned last week. Less efficient thermodynamically, but may be more economical if "lower-grade" heat is available.

This week... HVAC for Smaller Buildings

MEEB: Cooling-Only Systems

> Fans
> Evaporative Cooling
> Unit Air Conditioners

Heating-Only Systems

> Simple combustion (Wood)
> Electrical Resistance (Convection)
> Electrical Resistance (Radiant)
> Gas-fired heaters
> Hot Water “Hydronic” (Radiant or Convetion)

and of course... > Warm (Forced) Air Heating

This week... HVAC for Smaller Buildings

MEEB: Heating/Cooling Systems

> Cooling Coils Added to Warm-Air Furnaces
> Hydronic heating and coils

> Air-Air Heat Pumps
> Ground Source Heat Pumps (Geothermal)
> Water-source Heat Pumps

Heat pump use during the heating season is typically constrained by lower temperatures; below about 40° F the system must be supplemented by either combustion or resistance-fed heating due to the difficulty of absorbing heat in cold weather.

This week... HVAC for Smaller Buildings

So what does that mean for when you go out into professional practice...?

This week... HVAC for Smaller Buildings

~~MEEB~~: Reviewing the State of the Art

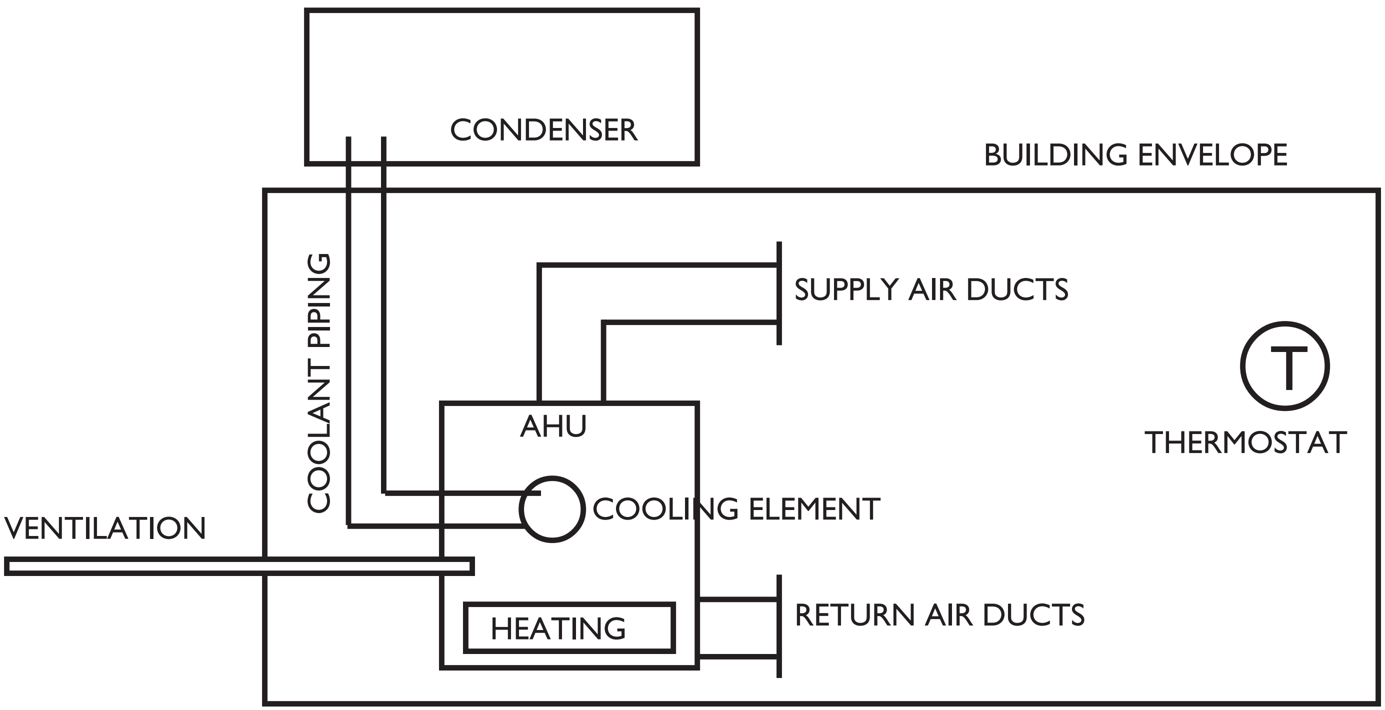
> Most buildings will, for economy's sake, seek to combine heating and cooling in a single, forced-air delivery system.

> Most systems will, for pragmatism's sake, split the condensing machinery from the air-handling machinery.

> On the other hand, these systems introduce heating at the location of the air handler.

This week... HVAC for Smaller Buildings

~~MEEB~~: Diagram of a typical HVAC System

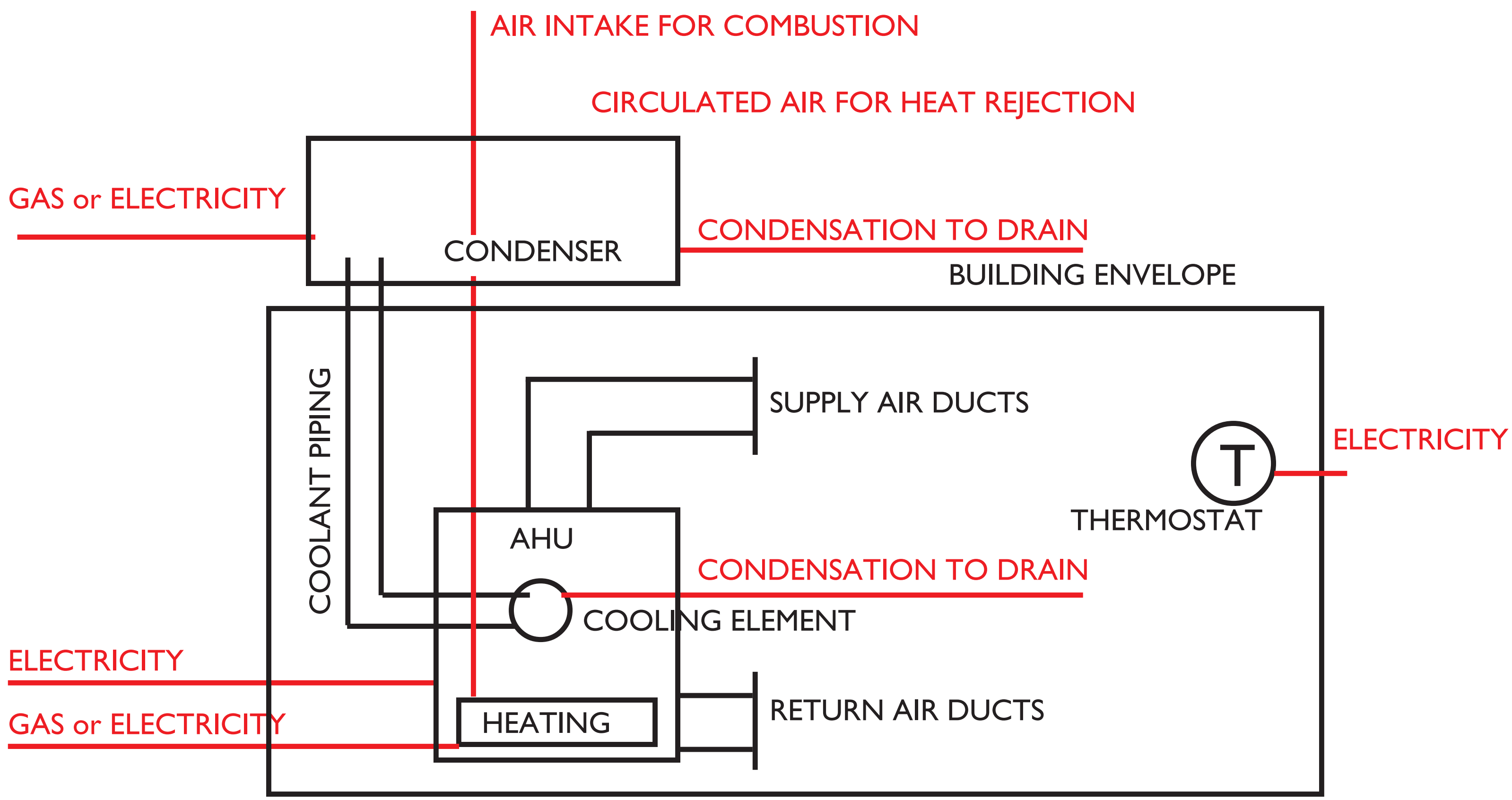


In most cases, the system is "split" between the condensing unit and the Air Handling Unit (AHU).

This week... HVAC for Smaller Buildings

~~MEEB~~: Systems Support for typical HVAC System

These systems don't work without additional technical infrastructure to support their operation.



This week... HVAC for Smaller Buildings

~~MEEB~~: **Individual Nomenclature for HVAC Equipment**

AHU (Air Handling Unit)

Typically, one for each Zone.
Each AHU is slaved to a Thermostat, which responds to the conditions in that zone.

Each AHU consists of a fan, heat-exchanger (which may be a cooling coil, heating manifold, or both), filter, condensation collection piping, supply output openings, and return air openings.

Each AHU also includes an electrical panel and hook-ups, and an access panel for service.

This week... HVAC for Smaller Buildings

MEEB: Individual Nomenclature for HVAC Equipment

Condenser (Chiller, Heat Exchanger)

Produces chilled water or coolant for use by AHUs located elsewhere

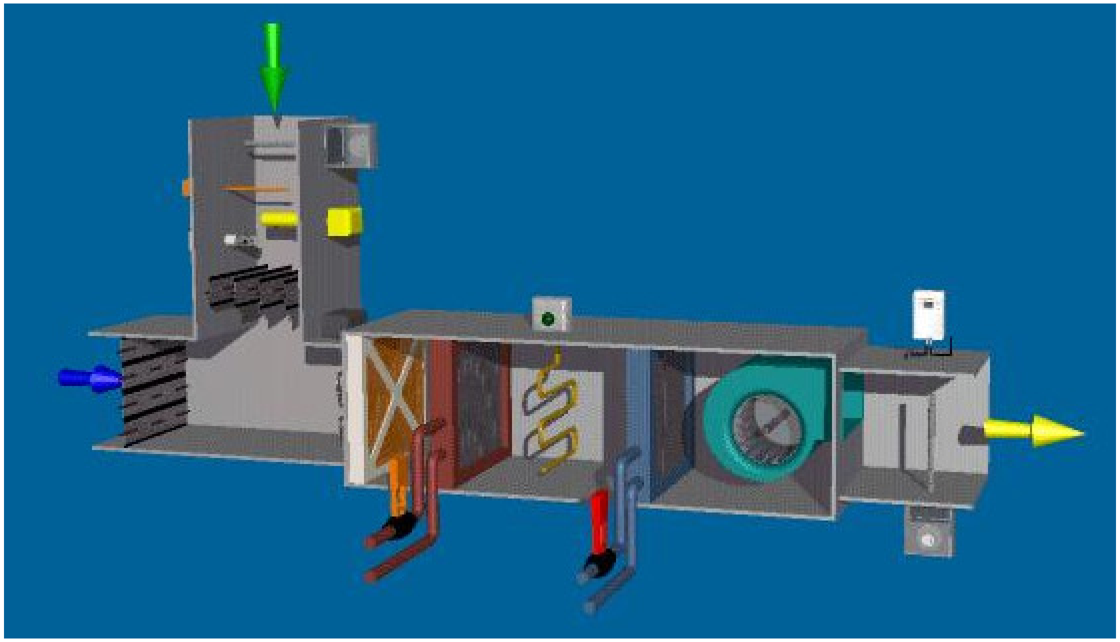
May serve the entire building, or individual AHUs.

Uses exterior air to reject heat created by the cooling cycle.

Includes intricate surfaces similar to a car radiator.

May be simple (a single box, with manifold, pump, and electrical panel) or complicated (multiple pumps and manifolds, pumps, and panels, with cooling towers and chillers).

Connected to significant coolant piping, which may require separate pumps.



Schematic Diagram of AHU (Air Handling Unit)

Domestic Split System

Comercial, Rooftop AHU

Comercial, Rooftop Condenser

This week... HVAC for Smaller Buildings

~~MEEB~~: Individual Nomenclature for HVAC Equipment

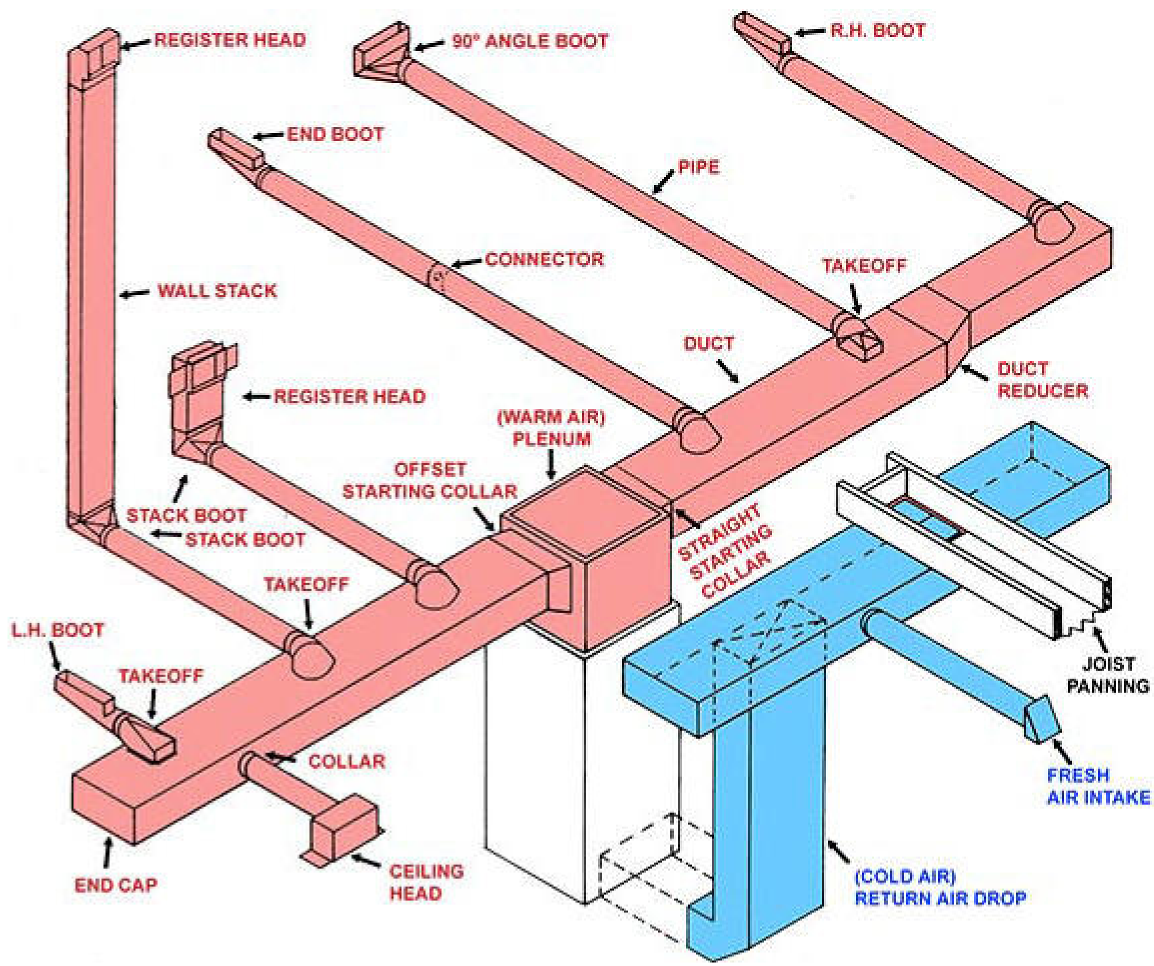
Ductwork: Supply and Return

Each AHU forces air into a "supply" duct, the largest of which is called " trunk line," like the trunk of a tree.

These ducts, typically galvanized steel, thread though enclosed spaces throughout the building and deliver "supply air" through louvered openings called "supply grilles" or "registers."

A parallel network of ducts, called "return" ducts, remove "used" air under negative pressure for return to the AHU.

Typical Domestic Duct Configuration



Typical Duct Installation in a Commercial & Domestic Environments

This week... HVAC for Smaller Buildings

~~MEEB~~: Individual Nomenclature for HVAC Equipment

Ductwork: Other Considerations

Most ductwork is rigid, to preserve air velocity alongthe path of the supply run; some ductwork, especially at the “end” of the supply run, may be flexible -- hence the term “flex-duct”.

Ductwork in exterior conditions must be insulated. Some interior supply ductwork may be insulated. Insulation adds 2” minimum to required spatial cross section...

Ductwork cross section decreases as the air moves from the main trunk, since with each diffuser, less air volume need be accomodated.

This week... HVAC for Smaller Buildings

~~MEEB~~: Individual Nomenclature for HVAC Equipment

Coolant Piping

DON'T FORGET! All split-system HVAC configurations require supply and return of chilled water or coolant. Since the temperature of these pipes are well below the dewpoint of most interior environments, they are almost always insulated.

In commercial contexts, supply/return piping can be VERY LARGE and VERY HEAVY -- and may affect structural design due to their weight and to the necessity of providing suitable support.

Typical domestic cross section: 1/2" to 1"; typical commercial cross section: 1", 2" up to 8" at the trunk!

This week... HVAC for Smaller Buildings

~~MEEB~~: Individual Nomenclature for HVAC Equipment

Condensation Drainage

Ironically, the most "innocent" by-product of typcal HVAC systems can often cause the most construction-time installation head-aches due to Architect's lack of consideration. Condensation must be accounted for both at the main exterior condenser AND at all interior points of heat exchange -- ie, AHUs and local fan-coil units, which are like single-room AHUs.

Where does the condensation go -- Sanitary Line or Stormwater?

In any case, it must go *somewhere*.

Condensation Line from attic-mounted AHU, with insulated flex-ducts snaking around to their supply points.

Condensation Line with trapped connection to ... whatever.

This week... HVAC for Smaller Buildings

MEEB: Individual Nomenclature for HVAC Equipment

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Where does the condensation go -- Sanitary Line or Stormwater?

In any case, it must go *somewhere*.

This week... HVAC for Smaller Buildings

~~MEEB~~: Quick Summary of Important Concepts

> What goes out must come back: Supply air serves tempered air to occupied space; the same volume of "used air" must return to the AHU for reconditioning.

*Therefore, we speak of "**return air**" the design for which may be non-trivial.*

> Architects must find space for ducts in the same way we must find spaces for people. Architects must consider ALL the systems simultaneously: HVAC, Structure, Plumbing, and Electrical systems. Otherwise... CRASH!

This week... HVAC for Smaller Buildings

Now in Class:

Worksheet #9:
(Chapter 9)

Viva la Revolucione!

PBS Video Series: ***Design E²***

This week's showing: Green For All

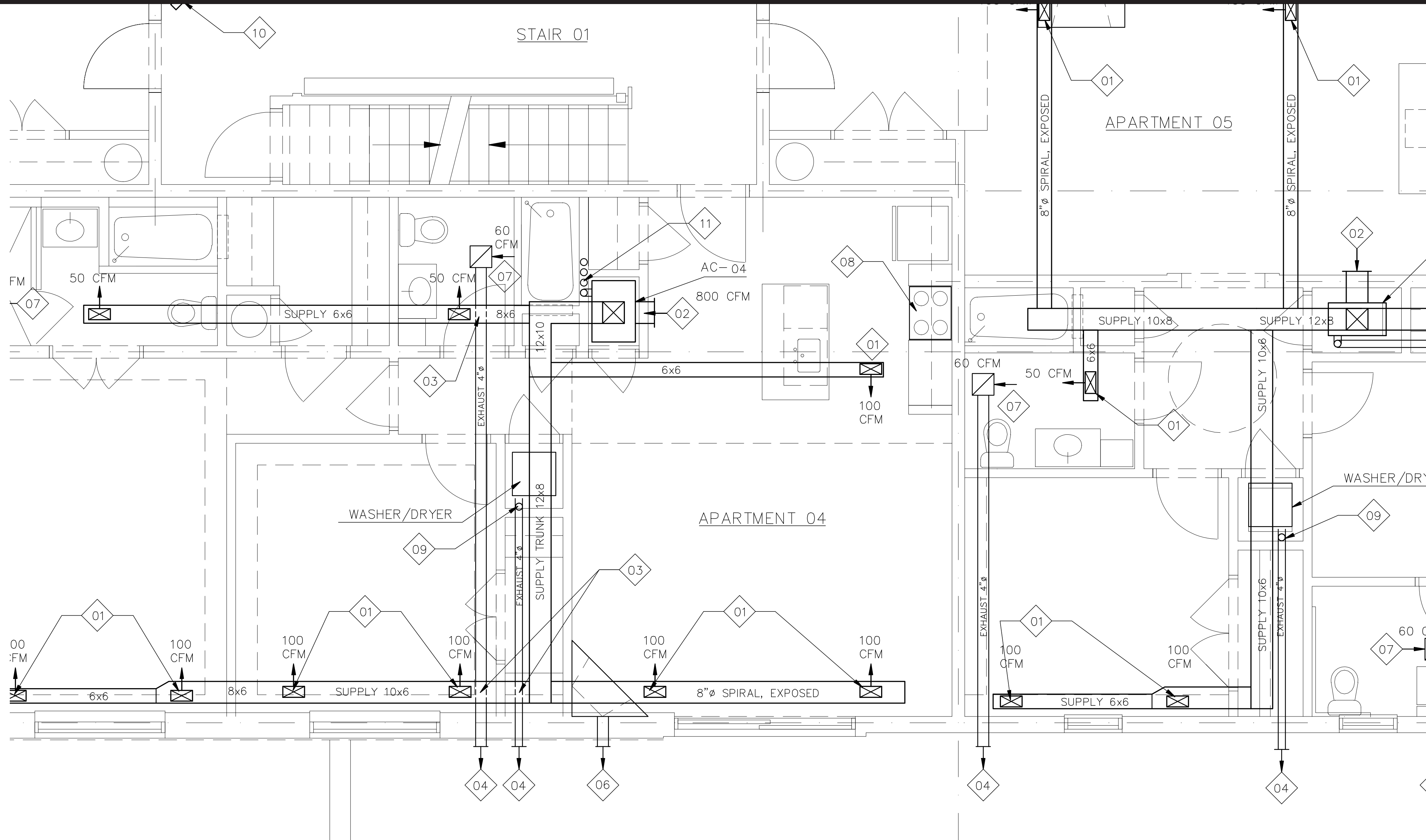
This week... HVAC for Smaller Buildings

Case Study of a Small Apartment Building

So far, this course has been a bit top-heavy with theory, with little practical information. One of the consequences of presenting material this way is that students only have *verbal* tools with which to discuss or absorb information. Naturally, as Architects, our professional language also includes a significant graphic component.

So: What do HVAC systems look like -- *on paper?*

Architectural Technology III



Hampden Hills Apartments

This week... <u>HVAC for Smaller Buildings</u>

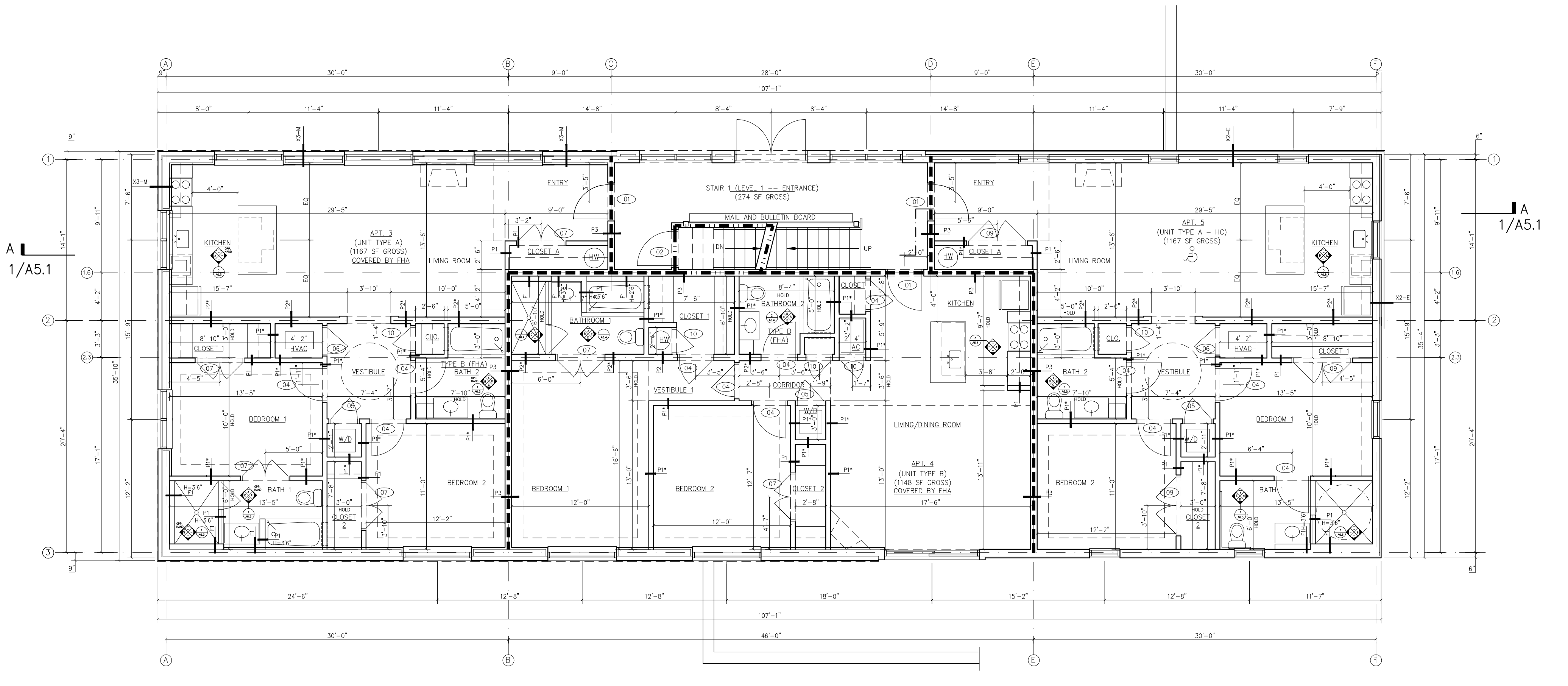
Hamdpen Hills Apartment

11 Units, New Construction, Market-Rate (Private Development)

Each unit ~ 1000 sf., 2 Bedroom, with 2 unit types.

All systems conventional mechanical systems (no passive solar or other sustainable technologies), independent and sized for each of the domestic units.

Aaaargh!



1 ***PLAN: FIRST FLOOR LEVEL (ENTRY) , $\frac{1}{4}$" = 1'0"***

DRYWALL PARTITION TYPES

P1 (*) 1/2" GWB EACH SIDE 2x4 STUD, 16" OC (*) WITH ACOUSTIC BATT INSULATION

P2 (*) 1/2" GWB EACH SIDE 2x6 STUD, 16" OC (*) WITH ACOUSTIC BATT INSULATION

P3 1 HOUR SEPARATION PARTITION: 1 LAYER 5/8" TYPE-X GWB EACH SIDE 2x6 STUD, 16" OC; FILL CAVITY WITH ACOUSTIC INSULATION

P4 1 HOUR SEPARATION PARTITION: 1 LAYER 5/8" TYPE-X GWB EACH SIDE 2x4 STUD, 16" OC; FILL CAVITY WITH ACOUSTIC INSULATION

P5 2 HOUR SEPARATION PARTITION: 2 LAYERS 5/8" TYPE-X GWB EACH SIDE 2x6 STUD, 16" OC; FILL CAVITY WITH ACOUSTIC INSULATION

DRYWALL FURRING TYPES

F1 FURRED SURFACE: 1/2" GWB ONE SIDE OF 2x4 STUDS, SPACED 16" OC

F1-X FURRED SURFACE AT EXTERIOR WALLS: 1/2" GWB ONE SIDE OF 2x4 STUDS, SPACED 16" OC; VAPOR BARRIER BETWEEN GWB AND STUDS; BATT INSULATION BETWEEN STUDS

F2 FURRED SURFACE: 1/2" GWB ONE SIDE OF 2x6 STUD, SPACED 16" OC

F3 FURRED SURFACE: 1/2" GWB ONE SIDE OF 2x4 STUDS, LAID FLAT, SPACED 16" OC

F3-X FURRED SURFACE AT EXTERIOR WALLS: 1/2" GWB ONE SIDE OF 2x4 STUDS, LAID FLAT, SPACED 16" OC; VAPOR BARRIER BETWEEN GWB AND STUDS; 1" RIGID INSULATION BETWEEN STUDS

BLOCK PARTITION TYPES

B1 8" CMU WALL: 2-HR RATING

EXTERIOR WALL TYPES

X1-E 1/2" GWB INSIDE FACE SIDE 2x4 STUD, 16" OC; VAPOR RETARDER BETWEEN GWB AND STUDS; BATT INSULATION BETWEEN STUDS; 1/2" EXTERIOR SHEATHING; EIFS-COMPATIBLE WEATHER BARRIER; EIFS SYSTEM INCLUDING 2" EPS INSULATION.

X2-E 1/2" GWB INSIDE FACE SIDE 2x6 STUDS, 16" OC; VAPOR RETARDER BETWEEN GWB AND STUDS; BATT INSULATION BETWEEN STUDS; 1/2" EXTERIOR SHEATHING; EIFS-COMPATIBLE WEATHER BARRIER; EIFS SYSTEM INCLUDING 2" EPS INSULATION.

X3-M 1/2" GWB INSIDE FACE SIDE 2x6 STUDS, 16" OC; VAPOR RETARDER BETWEEN GWB AND STUDS; BATT INSULATION BETWEEN STUDS; 1/2" EXTERIOR SHEATHING; WEATHER BARRIER; AIR GAP; 4" MASONRY VENEER.

X4-M 8" CMU; FILL CELLS WITH BLOCK-CAVITY INSULATION; BRUSH-APPLIED WATERPROOFING AT EXTERIOR FACE; AIR GAP; 4" MASONRY VENEER.

X5-M 12" CMU WALL: RETAINING WALL WATERPROOF MEMBRANE AT EXTERIOR FACE; DRAINAGE BOARD

EXTERIOR (BELOW-GRADE)

INTERIOR

PARTITION / WALL SCHEDULE **2**

Draft G.1 -- Construction Phase
February 10 2008

A2.2 **PLANS FIRST FLOOR**

Hampden Hill Apartments
3716 Elm Avenue
Baltimore, MD 21211

Jeremy Kargon, Architect
3418 Roland Avenue
Baltimore, Maryland 21211

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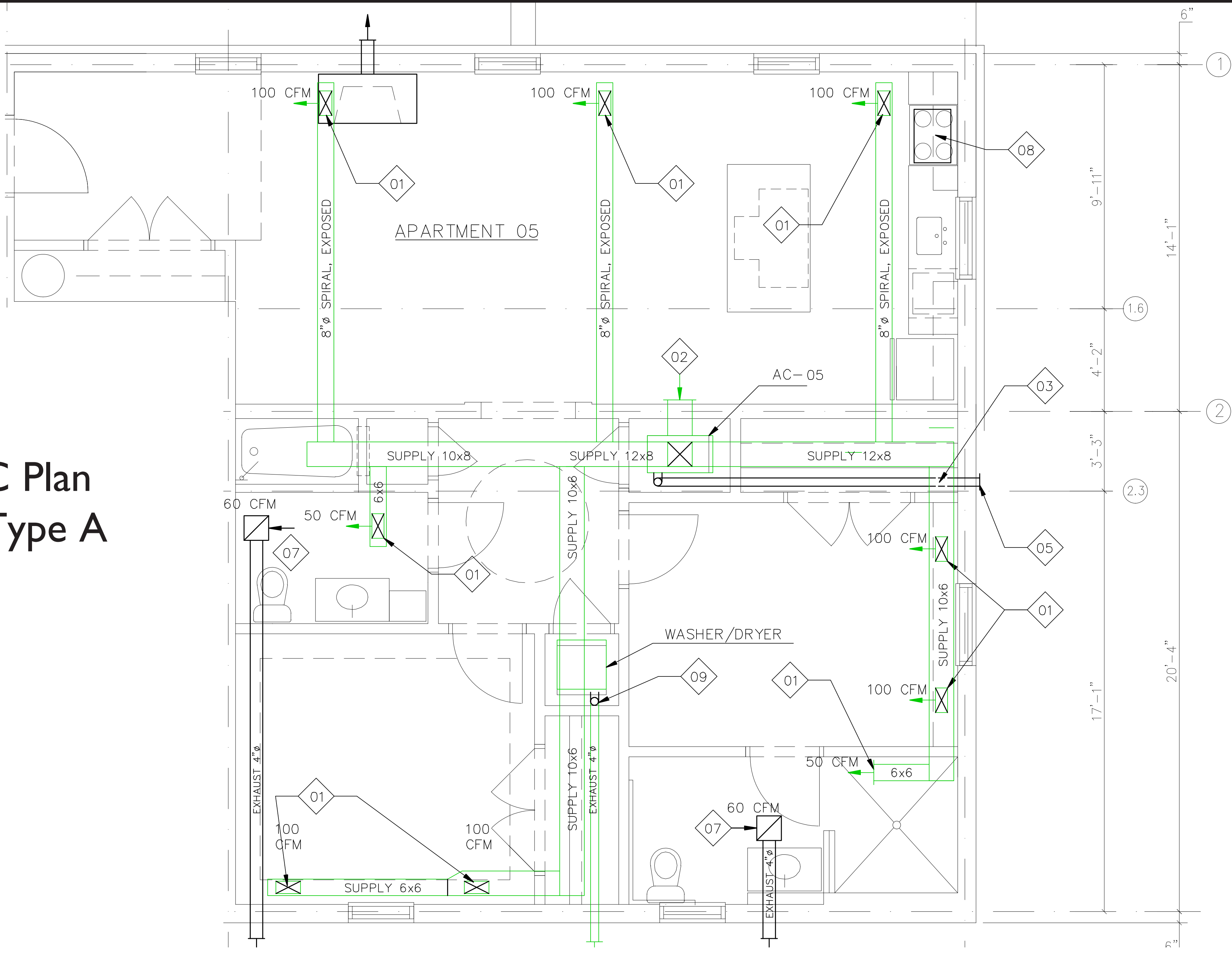
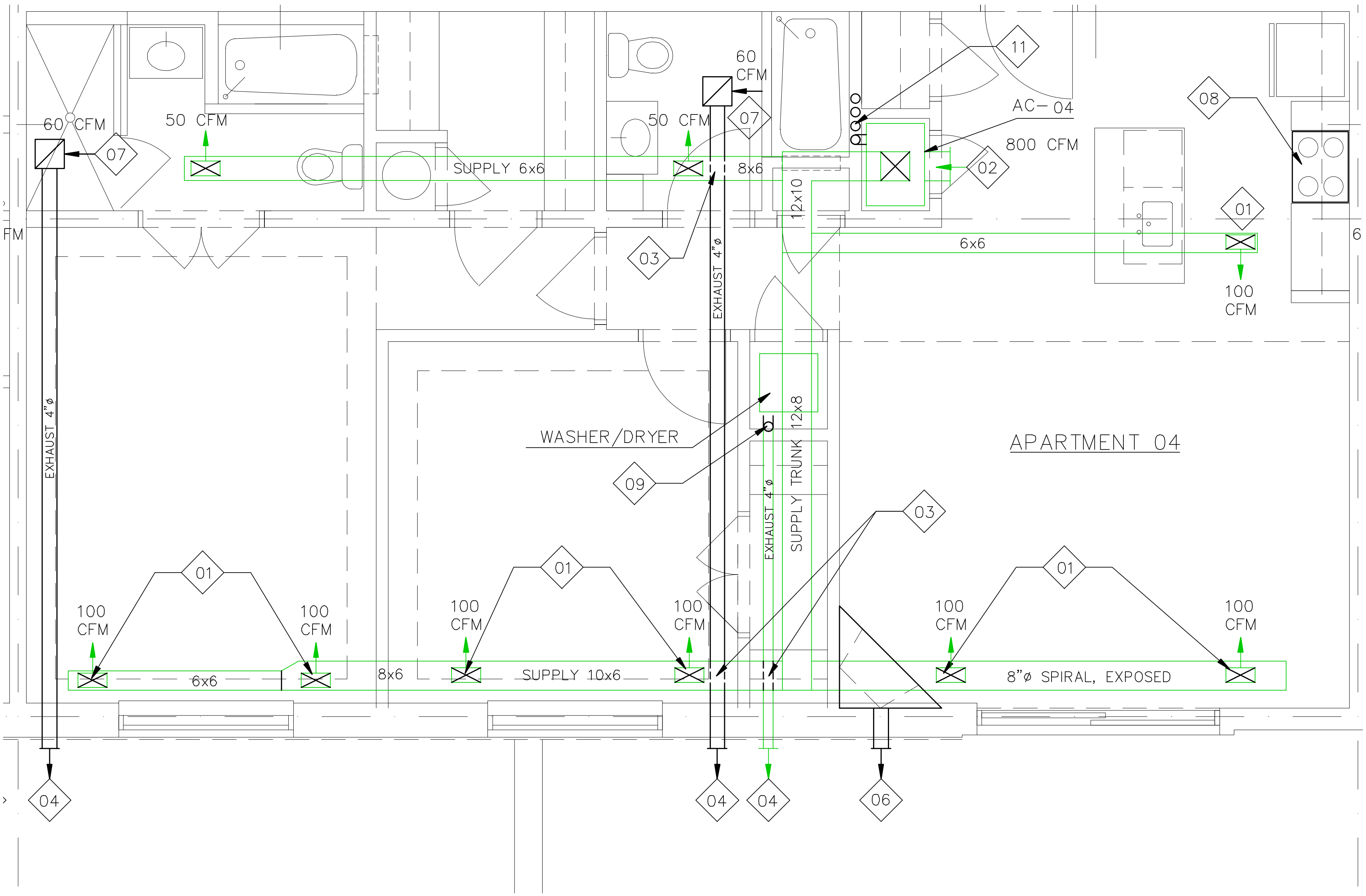
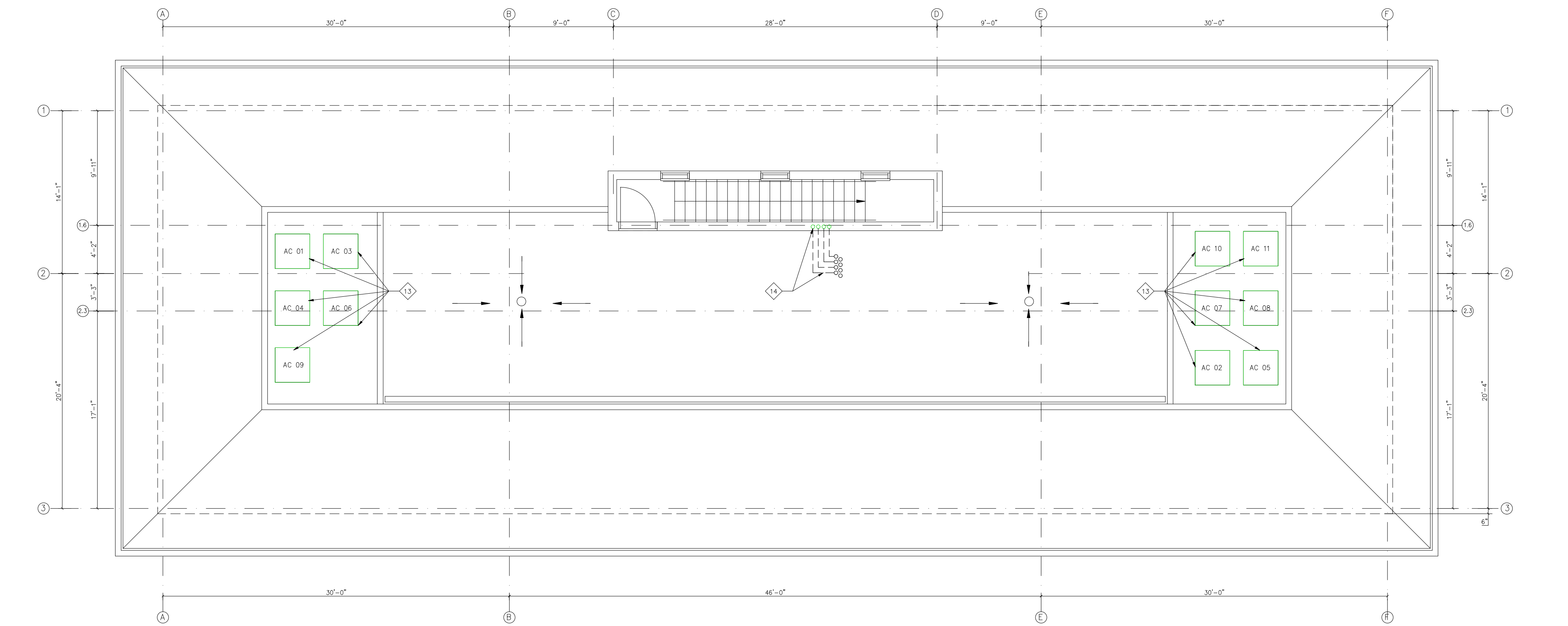
HVAC Plan
Unit Type A





HVAC Plan Unit Type B



1 ***PLAN: ROOF DECK LEVEL, $\frac{1}{4}$" = 1'0"***

N

Mechanical Annotations

ALL DUCTWORK SHALL BE MOUNTED BELOW 1-HOUR FLOOR/CEILING ASSEMBLY, UNLESS OTHERWISE NOTED.

- 01 AIR DIFFUSER, 4"x 8": CEILING, WALL, OR DUCT-MOUNTED
- 02 WALL-MOUNTED RETURN-AIR GRILLE, 14"x36"
- 03 VENT PIPING TO PASS BELOW DUCT
- 04 WALL-MOUNTED EXHAUST-VENT HOOD
- 05 COINCENTRIC INTAKE/EXHAUST FOR HI-EFFIC. FURNACE.
- 06 EXTERIOR EXHAUST/INTAKE FOR OPTIONAL GAS FIREPLACE
- 07 BATHROOM FAN/VENT INTAKE:
- 08 KITCHEN HOOD, NON-VENTED; CHARCOAL-FILTER; TASK LIGHT.
- 09 DRYER VENT HOOK-UP (<10' TO EXTERIOR EXHAUST)
- 10 WALL-MOUNTED ELECTRIC SPACE HEATER WITH THERMOSTAT (500/1000W)
- 11 INTAKE/EXHAUST FOR HI-EFFIC. FURNACE, EXTEND TO ROOF. 2-HR ENCLOSURE TO SURROUND VERTICAL PIPING GROUP.
- 12 [OMITTED]
- 13 ROOF-MOUNTED CONDENSING UNITS
- 14 FURNACE INTAKE/EXHAUST OFFSET BELOW ROOF TO CONTINUE TO PENTHOUSE STRUCTURE; EXTEND TO PENTHOUSE ROOF

ALL RESIDENTIAL UNITS:
Single-Zone Forced-Air System (Ducted Supply and Return)

All Mechanical and Plumbing work shall performed per prevailing codes of Baltimore City. Contractor shall confirm required sizing, specifying, and installation of systems indicated here. Room-by-room loads and air-flow to be determined using *ACCA Manual J* calculation procedures; equipment sizing according to *ACCA Manual S*.

Plans and diagrams on these drawings indicate constraints and suggested pathways for ducts, piping, and fixture location. Contractor shall conform to Architect's intention with regard to these constraints. Contractor shall be responsible for final location of all supply registers, return grills, all ductwork, piping, and all fixtures and fittings in order to supply a working system according to the above-mentioned design standards.

Contractor shall supply to Architect a written description of proposed system, and shall only proceed with installation upon Architect's written approval.

Heating: High-Efficiency Gas Furnace, *Model XR 90* by Trane or EQ
40,000 BTU for all units.

AC: Exterior Condensing Unit, Model XR12 by Trane or EQ
SEER 13 Rating Minimum: 2-Ton Units, unless otherwise noted.

All Bathrooms:
In addition to heating and cooling, all Bathrooms and WCs will be provided with mechanical fan ventilation, operable by a separate, wall-mounted switch.

All Kitchens:
In addition to heating and cooling, all Kitchens shall have non-vented hoods suspended over cooktop appliances. Hoods shall be supplied with charcoal-filter for recirculated air.

ADDITIONAL AREAS REQUIRING CLIMATE CONTROL:

ALL FLOORS Stair 0 and Stair 1, Including Entry :
These areas will be provided with a wall-mounted electric space heater with thermostat. [Model HM1-10-32 Ultra Thin Micathermic Heater (500/1000 W) by *Soleus Air Products*, or EQ.]

BASEMENT Water Service and Sprinklers :
This room will be provided with a wall-mounted electric space heater with thermostat. [Model HM1-10-32 Ultra Thin Micathermic Heater (500/1000 W) by *Soleus Air Products*, or EQ.]

Draft E -- Construction Phase
April 1 2008

M2.5

M PLANS
ROOF LEVEL

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