Department of Public Safety

Introduction to Residential HVAC System Basics

by

State Building Inspector

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THE BOLD LOOK OF KOHLER
HIGH EFFICIENCY
AIR CLEANER
20 x 25 x 4


TENNSMITH
CAUTION


FABRICATION


TENNSMITH


5 on 10
20 on 32

Introduction to Residential HVAC System Basics

How they are affected by the I-Codes

- 2009 International Residential Code
- 2009 International Mechanical Code
- 2012 International Energy Conservation
- Code 780 CMR 8th Edition Amendments

Introduction to Residential HVAC Systems

And how they are affected by the I-Codes

- **HVAC Science Basic** "Rule of Thumb"
- **BTU** = The energy required to raise the temperature of one pound of water 1 degree fh 1hr at sea level
- **43 BTUs** per sq ft. of habitable space
- **Absolute Zero** = absence of heat -459.6 f *(very cold!)*

Introduction to Residential HVAC Systems

And how they are affected by the I-Codes

- **1-TON of Cooling** = The energy required to melt a one ton (2000lbs) ice block in a 24hr period
- (144 BTU per pound x 2000lbs = 288,000 divided by 24hrs = 12,000 BTUs per hour)
- 400 CFM per TON of cooling
- **Cooling Tonnage** - one ton of cooling for every 700 sq. ft. (could be more but no less for rule)
- **Ventilation design basics** (again for the rule of thumb) Heating Supply/Return 100/80% Cooling 80/100% Supply/Return "the bicycle wheel effect"

Introduction to Residential HVAC Systems

And how they are affected by the I-Codes

- **"Rule of Thumb"** Air Duct Calculation 7" dia. Duct = 150 cfm, 8" dia. duct = 200 cfm and 9" dia. duct 300 cfm

- **"Rule of Thumb"** duct sizing 1sq. ft. = 1 CFM (probably less again this is a rule of thumb) always require a Manual "J" heat loss calculation. The contractor/designer should also use a Manual "S" for proper equipment selection and sizing, a Manual "D" for proper Duct Sizing

- **PSI Hydronic "Rule of Thumb"** 1 lbs of pressure lifts water 4.5 feet minimum boiler water pressure for a two story house is 12 pounds (industry standard is working pressure 15-25lbs relief valve set at 35lbs)

Introduction to Residential HVAC Systems

And how they are affected by the I-Codes

DISCLAIMER!!!

- These examples are **"rules of thumb"** they are developed for reasonable code compliance.
- They should not be used for designing a system.

Mechanical Aspects of Residential HVAC System

- **Basic Components of the Warm Air Furnace:**

  Burner and Controls, High Limit Switch/ Low Limit Switch, Heat Exchanger and or Heating Box, Blower, Return air Inlet, Filter, Warm air Outlet and the Flue Connection.

- **Basic Theory of the Warm Air Furnace:** Thermostat call for heat, the controls energize the burner heating the heat exchanger to the point that the pre-set bi-metal switch connects or "makes" to energize the blower sending warm air through the plenum into the ducts into the living area and finally satisfying the thermostat shutting off the furnace.

Mechanical Aspects of Residential HVAC System

- **Basic Components of the Hydronic Boiler**:

  Burner and Controls, Combustion Chamber, Hydronic Heat Exchanger (Tubes, Finns or Pins), Circulator Pumps, Air Scoops, One way Check valves, Back Flow Preventer, Supply Water Cut-off, Aquastat, Pressure Reducing Valve, Relief Valve, Hydronic piping connecting to the Base Board Fin-Tube Units.

Mechanical Aspects of Residential HVAC System

- **Basic Theory or the Hydronic Boiler:**
- Thermostat calls for heat the controls energize the burner heating the combustion chamber heating the hydronic heat exchanger and heating the water in the heat exchanger reservoir, the water heats to the point that the aquastat switch connects or "makes" at this time the aquastat energizes the circulator pump and warm water flows through the hydronic piping connecting to the base board heating units sending the heated water to the bas board fin tube units the heat is transferred by way of convection from the fin tubes base boards to the living area the water is then returned to the boiler to start the process over again until the thermostat is satisfied. As a note most hydronic boilers are "warm start" Boilers, that means the water in the boiler stays heated at a pre-determined temperature so it is ready to heat the system when there is a call for heat. The "warm start" boilers are usually fitted with a direct water heater (which means the domestic hot water coil is in the boiler's water jacket) or an indirect hot water heater (which means the domestic hot water coil is place outside or indirectly placed outside of the hydronic boiler's water jacket) this makes for a very efficient way to supply domestic hot water to the residence.

Mechanical Aspects of Residential HVAC System

- **Basic Components of the Hydro-Air System:**

  The Hydro Air System is a Hybred that combines the benefits of the hydronic boiler and the ventilation system of the warm air system. They accomplish this by using a hydronic boiler to heat a hydronic heat exchanger that is place in the plenum of the duct work, the air handler then blows air over the heat exchanger's coil warming the air in the plenum through the duct and heating the Living Area.

Mechanical Aspects of Residential HVAC System

- **Basic theory of the Hydro-Air System**:

  The hydro air system is a hybrid system using the benefits of both the warm air furnace and the hydronic boiler. By placing a hydronic heat exchanger in the plenum of the duct work typically used for a warm air system the resident has the benefit and comfort of the hydronic system along with the practicality of the warm air system. Let's see how it works. As with both previous designs the thermostat calls for heat the hydronic boiler's controls energize the burner the burner then heats up the combustion chamber the combustion chamber heats the hydronic heat exchanger which heats the water in the exchanger the aquastat is energized or "makes" energizing the circulator pumps the warm water is pumped thru the hydronic piping that is connected to the heat exchanger coil placed in the plenum of the duct work, the air handler blows air over the coils of the heat exchanger and heated air moves through the plenum into the branch lines though the ducts heating the living space until the thermostat is satisfied. Another major advantage of the hydro air system is the ductwork can also be used for your air conditioning system.

Mechanical Aspects of Residential HVAC System

- **Basic Components of the A/C System:**

  Thermostat, Compressor, Fan, Condensing Coil, Line Set and A-Coil (Evaporator)

- **Basic Air Condition Theory:**

  The compressor compresses the refrigerant gas putting it under heat pressure up to 200+ degrees fh!, the pressurized and heated refrigerant is then forced into the condensing coil, the fan in the condensing coil draws outside air in and it starts to cool the refrigerant cooling it to the point that the refrigerant begins to condense into a liquid state, by the time the refrigerant leaves the condensing coils it has been converted to a liquid state, the refrigerant now enters the supply line (liquid line) and is on its way, still under pressure, to the A-Coil Evaporator and this is where the magic happens. (Do you remember we were talking about boiling points?) The liquefied refrigerant enters the A-Coil Evaporator and is de-pressurized and yes you guessed it the refrigerant cools, cooling the A-coil in the plenum the air handler blows air over the coil's cooling fins and cools the living area, the refrigerant than goes to the suction line and back to the compressor where the process starts over again.

Mechanical Aspects of Residential HVAC System

- **Basic components of the Duct System:**

  Plenums: box like chamber connected to the furnace, two types return and supply should be dimensional compatible to the furnace and be at least 14” tall.

  Trunks: these are usually rectangular and connect to the plenum and run through the center of the house (usually in attic or basement).

Mechanical Aspects of Residential HVAC System

- **Branches:** smaller ducts could be round or rectangular and connect the trunk to the individual registers .
- **Dampers:** in a quality system there will be locking dampers found in each branch to allow for balancing of the system.
- **Boot:** connects the branch line to the conditioned space.
- **Register:** the finishing component to keep objects from falling into the boot, has an integral damper (usually found on the supply side) to help fine tune the system balance .
- **Supports:** duct supports shall be at least 1/2" wide 18 gage metal strap or 12 gage galvanized wire at intervals not to exceed 10 feet.


CLARK


RPm
UP

Mechanical Aspects of Residential HVAC System

- **Flexible Ducts vs. Flexible Connector:**

2009 IMC-603.6.1 "Flexible air ducts both metallic and non-metallic, shall be tested in accordance with UL 181. Such ducts shall be installed in accordance with IMC 304.1 (see hand-out). Flexible air ducts length shall not be limited but installed to manufactures instructions."

IMC 603.6.2 "Flexible air connectors, (not to be confused with IMC 603.6.1 Flexible air ducts) flexible air connectors have a lesser testing protocol than the testing protocol for flexible air ducts. The length of the flexible air connector is limited to 14 feet, flexible air connectors cannot pass through any walls, floors or ceiling, whether the assembly is fire rated or not. Flexible air connector is identified by the round or oval label, making them readily distinguishable from rectangular flexible air duct. Read more on this subject in the 2009 IMC Chapter 6.

4

Installation Guidelines

4.1 Code Reference

The "authority having jurisdiction" should be referenced to determine what law, ordinance or code shall apply in the use of flexible duct.

Ducts conforming to NFPA 90A or 90B shall meet the following requirements:

a. Shall be tested in accordance with Sections 5-21 of Underwriters Laboratories Standard for Factory-Made Air Ducts and Air Connectors, UL 181.
b. Shall be installed in accordance with the conditions of their listing.
c. Shall be installed within the limitations of the applicable NFPA 90A or 90B Standard.

4.2 General

The routing of flexible duct, the number of bends, the number or degrees in each bend and the amount of sag allowed between support joints will have serious effects on system performance due to the increased resistance each introduces. Use the minimum length of flexible duct to make connections. It is not recommended that excess length of ducts be installed to allow for possible future relocations of air terminal devices.

Avoid installations where exposure to direct sunlight can occur, e.g. turbine vents, sky lights, canopy windows, etc. Prolonged exposure to sunlight will cause degradation of the vapor barrier. Direct exposure to UV light from a source lamp installed within the HVAC system will cause degradation of some inner core/liner materials.

Terminal devices shall be supported independently of the flexible duct.

Repair torn or damaged vapor barrier/jacket with duct tape listed and labeled to Standard UL 181B. If internal core is penetrated, replace flexible duct or treat as a connection.

4.3 Installation and Usage

Install duct fully extended, do not install in the compressed state or use excess lengths. This will noticeably increase friction losses.

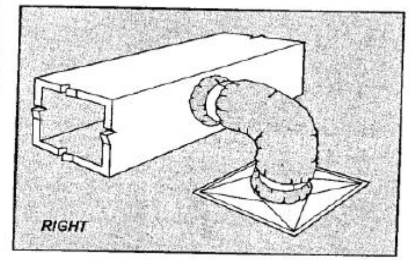


Figure 6

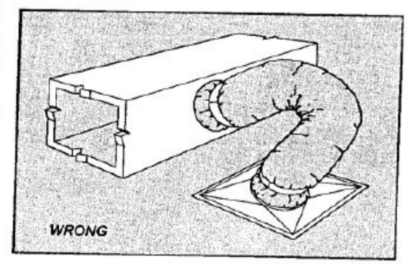


Figure 7

Figure 603.6(4)
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)
(Continued)

Installation Guidelines . . . continued

Avoid bending ducts across sharp corners or incidental contact with metal fixtures, pipes or conduits. Radius at center line shall not be less than one duct diameter.

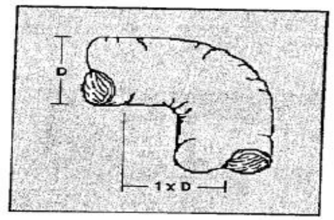


Figure 8

Do not install near hot equipment (e.g. furnaces, boilers, steam pipes, etc.) that is above the recommended flexible duct use temperature.

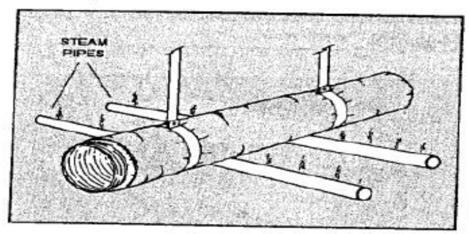


Figure 9

4.4 Connecting, Joining and Splicing Flexible Ducts

All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions.

For flexible ducts with plain ends, standardized installation instructions conforming to this standard are shown in Sections 4.5 "Nonmetallic With Plain Ends" (uses tape and clamp to seal/secure the core to the fitting), 4.6 "Alternate Nonmetallic With Plain Ends" (uses mastic and clamp to seal/secure the core to the fitting), and 4.7 "Metallic With Plain Ends (optional use of tape or mastic and metal screws to seal/secure the core to the fitting).

Due to the wide variety of ducts and duct assemblies with special end treatments, e.g. factory installed fittings, taped ends, crimped metal ends, etc., no standardized installation instructions are shown. Reference manufacturer's installation instructions.

All tapes, mastics, and nonmetallic clamps used for field installation of flexible ducts shall be listed and labeled to Standard UL 181B - Closure Systems for Use With Flexible Air Ducts and Air Connectors.

Sheet metal fittings to which flexible ducts with plain ends are attached shall be beaded and have a minimum of 2 inches [50 mm] collar length. Beads are optional for fittings when attaching *metallic* flexible ducts.

Sheet metal sleeves used for joining two sections of flexible duct with plain ends shall be a minimum of 4 inches [100 mm] in length and beaded on each end. Beads are optional for sleeves when joining *metallic* flexible ducts.

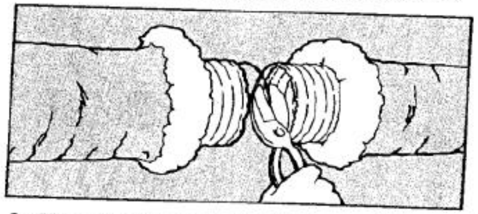
Flexible ducts secured with nonmetallic clamps shall be limited to 6 inches w.g. [1500 Pa] positive pressure.

Figure 603.6(4)—continued
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)
(Continued)

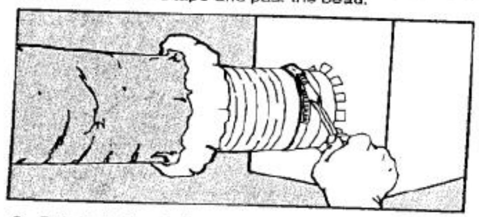
4.5 Installation Instructions for Air Ducts and Air Connectors - Nonmetallic with Plain Ends

Connections

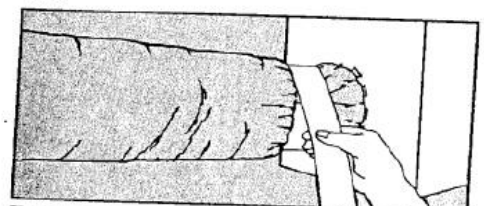
1. After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Fold back jacket and insulation.



2. Slide at least 1" [25 mm] of core over fitting and past the bead. Seal core to collar with at least 2 wraps of duct tape. Secure connection with clamp placed over the core and tape and past the bead.

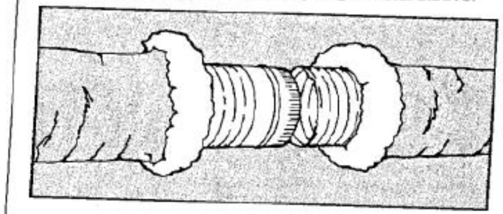


3. Pull jacket and insulation back over core. Tape jacket with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.

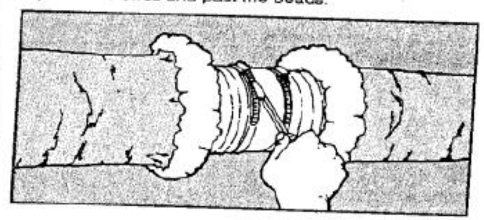


Splices

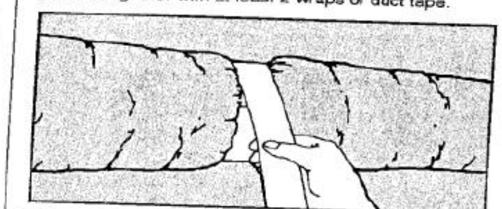
1. Fold back jacket and insulation from core. Butt two cores together on a 4" [100 mm] length metal sleeve.



2. Tape cores together with at least 2 wraps of duct tape. Secure connection with 2 clamps placed over the taped core ends and past the beads.



3. Pull jacket and insulation back over cores. Tape jackets together with at least 2 wraps of duct tape.



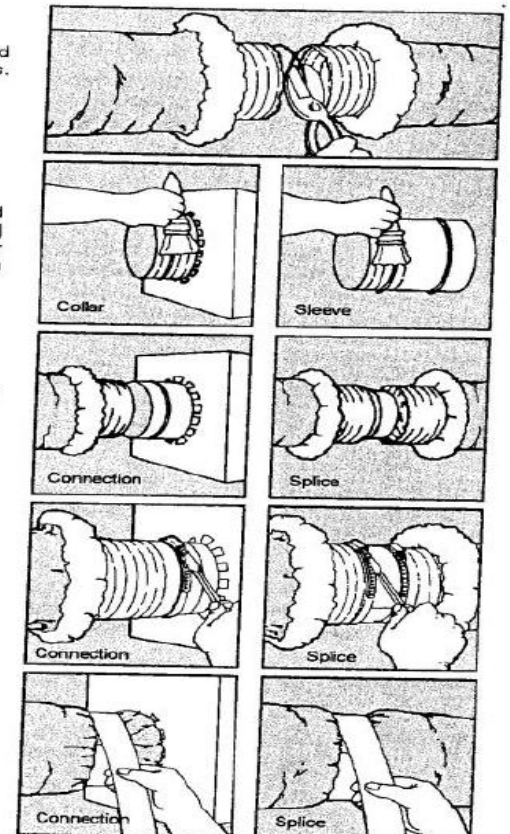
NOTES:

1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use beaded sheet metal fittings and sleeves.
3. Use tapes listed and labeled in accordance with Standard UL 181B and marked "181B-FX".
4. Nonmetallic clamps shall be listed and labeled in accordance with Standard UL 181B and marked "181B-C". Use of nonmetallic clamps shall be limited to 6 in. w.g. [1500 Pa] positive pressure.

Figure 603.6(4)—continued
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)
(Continued)

4.6 Alternate Installation Instructions for Air Ducts and Air Connectors - Nonmetallic with Plain Ends

Connections and Splices



Step 1
After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Pull back jacket and insulation from core.

Step 2
Apply mastic approximately 2" [50 mm] wide uniformly around the collar of the metal fitting or over the ends of a 4" [100 mm] metal sleeve. Reference data on mastic container for application rate, application thickness, cure times and handling information.

Step 3
Slide at least 2" [50 mm] of core over the fitting or sleeve ends and past the bead.

Step 4
Secure core to collar with a clamp applied past the bead. Secure cores to sleeve ends with 2 clamps applied past the beads.

Step 5
Pull jacket and insulation back over core ends. Tape jacket(s) with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.

NOTES:
1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use beaded sheet metal fittings and sleeves.
3. Use mastics listed and labeled in accordance with Standard UL 181B and marked "181B-M" on container.
4. Use tapes listed and labeled in accordance with Standard UL 181B and marked "181B-FX".
5. Nonmetallic clamps shall be listed and labeled in accordance with standard UL 181B and marked "181B-C". Use of nonmetallic clamps shall be limited to 6 in. w.g. [1500 Pa] positive pressure.

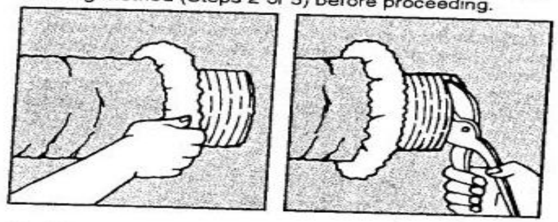
Figure 603.6(4)—continued
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)
(Continued)

Installation Guidelines . . . continued

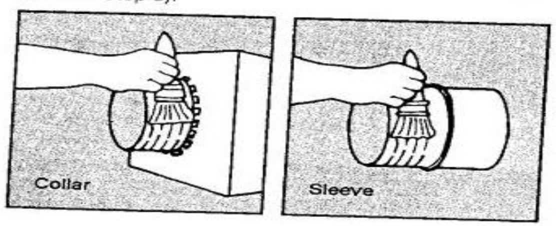
4.7 Installation Instruction for Air Ducts and Air Connectors - Metallic with Plain Ends

Connections and Splices

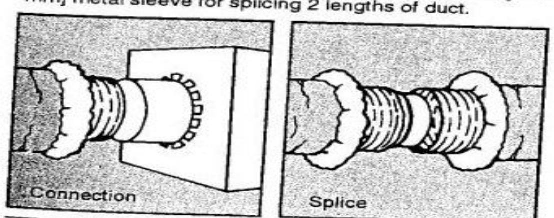
1. After cutting duct to desired length, fold back jacket and insulation exposing core. Trim core ends squarely using suitable metal shears. Determine optional sealing method (Steps 2 or 5) before proceeding.



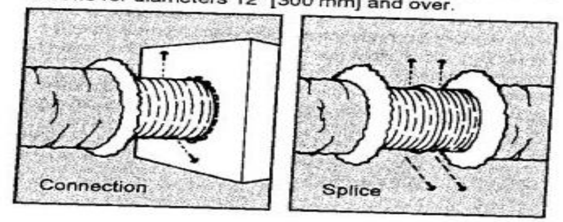
2. When mastics are required and for pressures 4" w.g. [1000 Pa] and over, seal joint with mastic applied uniformly to the outside surface of collar/sleeve. (Disregard this step when not using mastics and proceed to Step 3).



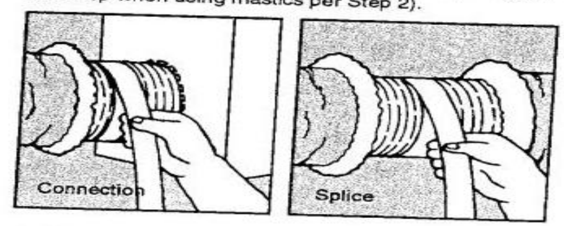
3. Slide at least 1" [25 mm] of core over metal collar for attaching duct to take off or over ends of a 4" [100 mm] metal sleeve for splicing 2 lengths of duct.



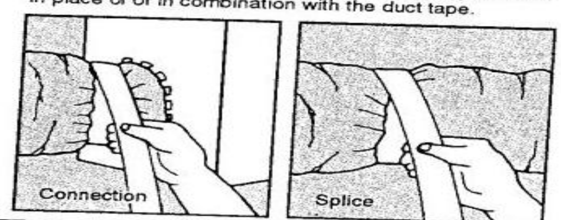
4. Secure to collar/sleeve using #8 sheet metal screws spaced equally around circumference. Use 3 screws for diameters under 12" [300 mm] and 5 screws for diameters 12" [300 mm] and over.



5. For pressures under 4" w.g. [1000 Pa] seal joint using 2 wraps of duct tape applied over screw heads and spirally lapping tape to collar/sleeve. (Disregard this step when using mastics per Step 2).



6. Pull jacket and insulation back over core. Tape jacket with 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.



NOTES:
1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use mastics listed and labeled to Standard UL 181B and marked"181B-M" on container.
3. Use tapes listed and labeled to Standard UL 181B and marked "181B-FX".
4. Nonmetallic clamps shall be listed and labeled in accordance with Standard UL 181B and marked "181B-C".

Figure 603.6(4)—continued
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)
(Continued)

4.8 Supporting Flexible Duct

Flexible duct shall be supported at manufacturer's recommended intervals, but at no greater distance than 5' [1.5 m]. Maximum permissible sag is ½" per foot [42 mm per meter] of spacing between supports.

A connection to rigid duct or equipment shall be considered a support joint. Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the center line of the bend.

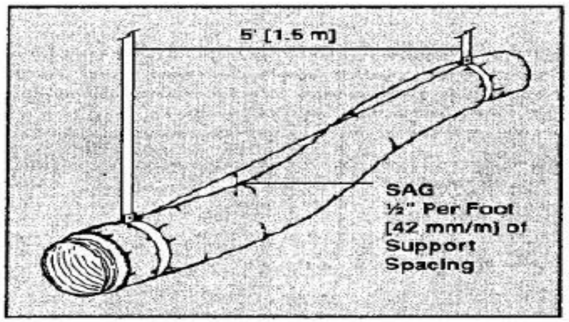


Figure 10

Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than 1½" [38 mm] wide.

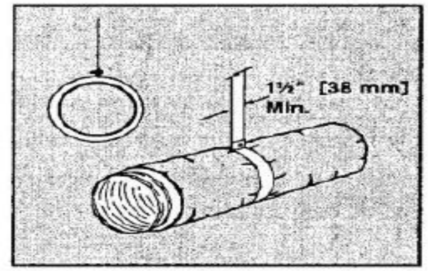


Figure 11

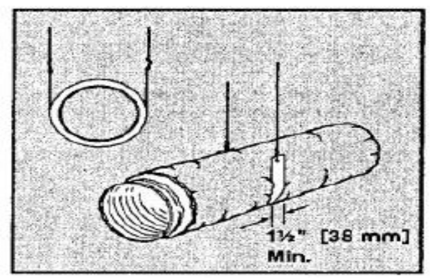


Figure 12

Figure 603.6(4)—continued
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)
(Continued)

Factory installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when manufacturer's recommended procedures are followed.

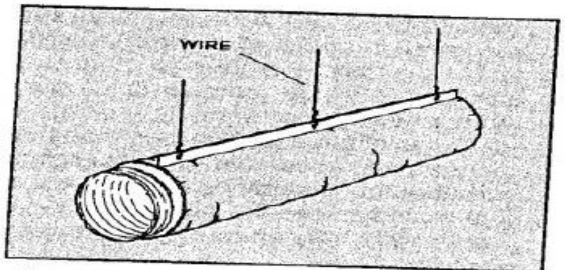


Figure 13

Flexible ducts may rest on ceiling joists or truss supports. Maximum spacing between supports shall not exceed the maximum spacing per manufacturer's installation instruction.

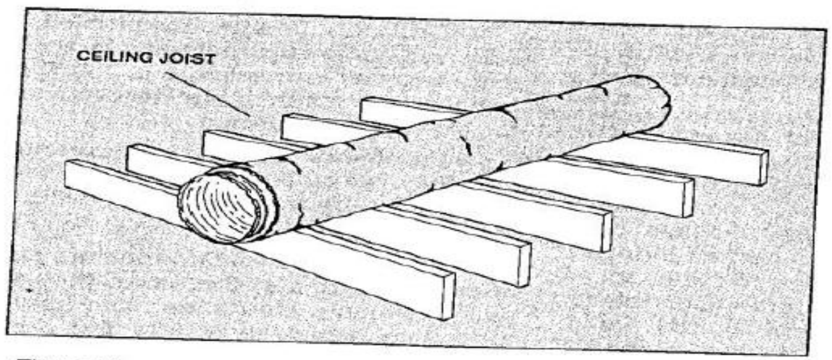


Figure 14

Support the duct between a metal connection and bend by allowing the duct to extend straight for a few inches before making the bend. This will avoid possible damage of the flexible duct by the edge of the metal collar.

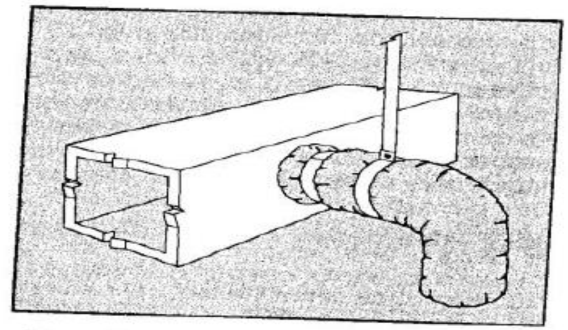


Figure 15

Vertically installed duct shall be stabilized by support straps at a max. of 6' [1.8 m] on center.

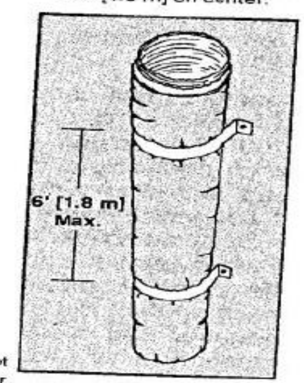


Figure 16

Note:
Factory-made air ducts may not be used for vertical risers in air duct systems serving more than two stories.

Figure 603.6(4)—continued
INSTALLATION INSTRUCTIONS FOR FLEXIBLE AIR DUCTS AND AIR CONNECTORS
(Courtesy of Air Diffusion Council)

Mechanical Aspects of Residential HVAC System

- **Ducts, Duct Sealing and Insulation Requirements:**
- IECC Duct Sealing Methods (2009 IRC M1601.4.1 and 2012 IECC-R403.2.2)
- M1601.4.1 “Joint and seams shall be air tight by means of Tapes, Mastics, Liquid Sealants, Gasketing and or other approved closure methods. Crimp Joints for round metal ducts shall have contact lap of at least 1-1/2” and shall have mechanically fastened by at least three screws or rivets equally spaced.
- The “What and Where” of Duct Insulation (2012 IECC- R403.2.1) “Supply ducts in attics shall be insulated to a minimum of R-8. All other ducts shall be insulated to a minimum of R-6 (exception: duct or portions therefore located completely inside the thermos-envelope. If any portion of the system is outside of the thermos-envelope the system must be duct tested.
- Installation of Flexible Ducts SMACMA Installation Guide (See Hand-out).

2009 International Residential Code

Heating & Ventilation Air Conditioning Equipment Sizing:

- IRC- M-1401.3
- ACCA- Manual-J
- ACCA Manual-S
- ACCA Manual-D

2009 International Residential Code

- **Heating and Cooling Sizing**

- Before you can start a plan review you must understand what you are reviewing. The 2009 IRC Chapter 14 sec.M1401.3 "Sizing" State that the heating and cooling equipment shall be sized in accordance with The Air Conditioning Contractors of America ACCA Manual "J" and ACCA Manual "S".

- Let's look into the Manual J load calculation. The Manual J load calculation contains a simplified method of calculating heating and cooling loads for winter and summer.

2009 International Residential Code

- **Designer's Objectives**
- To design a mechanical system that can add or remove heat energy at a rate that will allow the home's indoor environment to achieve the design conditions.
- This will keep the occupants comfortable and safe.

2009 International Residential Code

Root Cause Heat Transfer (flow of heat)

- A structure loses or gains heat in three ways:

- **Conduction -** When heat is transferred through walls, floors, ceilings, door and glass. It passes from warm areas to cooler areas.

- **Radiation -** When heat is transferred from its source to an object without heating the medium, a good example is the sun.

- **Convection -** When fluids or gases of different temperatures mix they assume the weighted average temperature.

2009 International Residential Code

How a House Gains Heat Summer

(see hand out)

- Roof
- Doors
- Windows
- Walls
- Floor
- Occupants
- Equipment

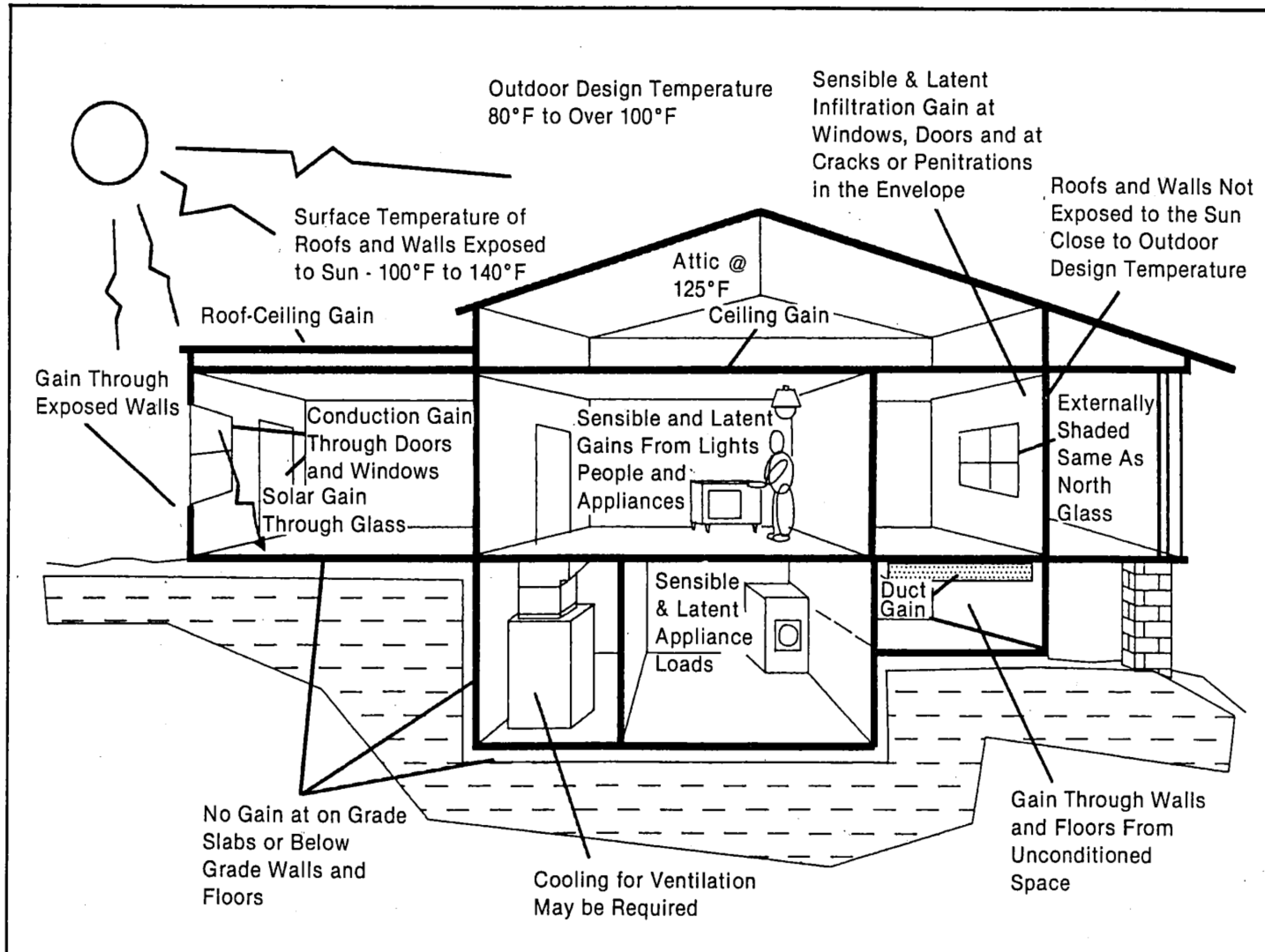


Figure 4-1 Summer Cooling Loads

2009 International Residential Code

How a House Looses Heat Winter

(see Hand out)

- Roof
- Doors
- Windows
- Walls
- Floor
- Equipment

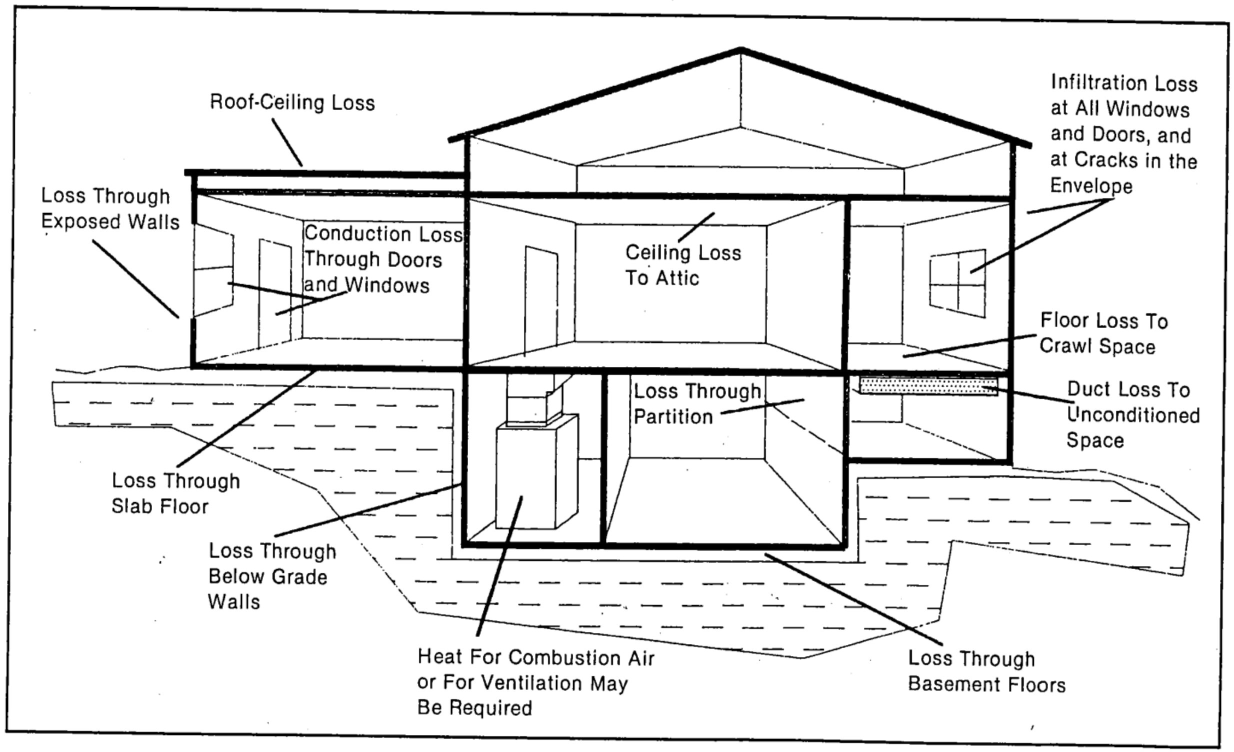


Figure 1-1 Winter Heating Loads

2009 International Residential Code

Applied Heat Transfer

- **SUMMER**

  Heat flows into the home

  "Sensible Heat"- dry heat (dry-bulb; thermometer)

  "Latent Heat"- wet heat (wet-bulb; humidity)

  Heat Gain so we need cooling

  WINTER

  Heat flows out of the home

  "Sensible Heat" only

  Heat loss so we need heating

2009 International Residential Code

It's The Science of Thermodynamics

- **First law of Thermodynamics:**

  "Energy can neither be created or destroyed, but can be converted from one form to another with some amount of heat given off during the conversion".

- **Second law of Thermodynamics:**

  "Over time, differences in temperature and pressure will decrease, leading to thermodynamic equilibrium".

2009 International Residential Code

It's The Science of Thermodynamics

- **First law of Thermodynamics:**

  "Energy can neither be created or destroyed, but can be converted from one form to another with some amount of heat given off during the conversion".

- **Second law of Thermodynamics:**

  "Over time, differences in temperature and pressure will decrease, leading to thermodynamic equilibrium".

Nature doesn't like temperature differences, so heat flows from one region of high temperature to a region of lower temperature until both are equal.

We don't like temperature differences, so we've designed objects and processes to slow this physical phenomena down. (i.e. Clothing, Shelter, Heating and Cooling).

2009 International Residential Code

The Big Question is:

What is a "LOAD CALCULATION"?

- Well in layman's terms- A load calculation is an account of the total heat flows into and out of a home (depending on the time of year)

- Why do we need to know the heating and cooling load calculation?

- The designer needs to know this rate in order to choose the correct equipment to make the occupants comfortable and safe (sounds familiar), to satisfy the building code and to keep energy cost down.

2009 International Residential Code

Manual "J" Load Calculation Method

- **Manual "J"** requires two sets of design conditions
- **Heat loss** (Winter Peak Loads)
- ***Heat loss** *(winter)* - Outdoor design temperature-heating 99% dry bulb (db)
- ***Indoor design temperature** - 70 degrees f db
- **Heat gains** *(Summer Peak Loads)*
- ***Heat gain** *(summer)* - Outdoor design temperature- cooling 1% db

***Indoor design temperature 75 degrees f db**

2009 International Residential Code

Design Temperatures

Outdoor Design Temperature

- Must be for the homes specific location
- 30 yr. average, compiled by ASHRAE
- Manual "J" Tables 1A and 1B
- Updated in 2014

Indoor Design Temperature

- Within the ASHREA comfort zone chart (per ANSI/ASHRAE 55 Thermal Environmental Conditions for Human Occupancy Standards).

2009 International Residential Code

Loads That Must Be Accounted For

As applicable for the specific structure:

- **Fenestration** (Windows, Glass Doors, Skylights)
- **Orientation of the structure:** What direction does the front door face N,S,E,W,… This is important because of the movement of the sun though-out the day , and it will have a huge effect on loads from windows, glass doors and skylights.
- **Opaque Panels-wood/metal doors**, above and below grade walls, partition walls, ceilings and floors.
- **Infiltration:** movement of heat through structure.
- **Ventilation** - mechanical and or manual.
- **Internal** - number of occupants.
- **Appliances, Equipment and Lighting.**

FORM J—1
Including Calculation Procedures A, B, C, D

1513 16th Street N.W.
Washington, D.C. 20036
Printed in U.S.A.
1986

Plan No. ____
Date ____
Calculated by ____

WORKSHEET FOR MANUAL J

LOAD CALCULATIONS FOR RESIDENTIAL AIR CONDITIONING

For: Name Example Problem
Address ____
City and State or Province ____
By: Contractor ____
Address ____
City ____

Design Conditions

Winter
Outside db -5 °F Inside db 70 °F
Winter Design Temperature Difference 75 °F

Summer
Outside db 88 °F Inside db 75 °F
Summer Design Temperature Difference 15 °F
Room RH 55% Daily Range M

Heating Summary

Total Heat Loss for Entire House (Line 15) = 47,808 Btuh
Ventilation CFM = none Winter Design Temperature Difference = ____ °F
Heat Required for Ventilation Air = 1.1 X ____ CFM X ____ °F = 0 Btuh
Design Heating Load Requirement = 47,808 (house) 0 (Vent) = 47,808 Btuh

Cooling Summary

Total Sensible Gain 16,669 Btuh (Calculation Procedure D)
Total Latent Gain + 3,835 Btuh (Calculation Procedure D)
Total = Sens. + Lat. = 20,504 Btuh.
Design Temperature Swings
Normal 3° (X) 4.5° ( )
Ventilation CFM = none

Equipment Summary

Make ____ Model ____ Type ____
Heating Input (Btuh) ____ Heating Output (Btuh) ____ Efficiency ____
Sensible Cooling (Btuh ____ Latent Cooling (Btuh) ____ Total (Btuh) ____
COP/EER/SEER/HSPF ____ Cooling CFM ____ Heating CFM ____
Space Thermostat Heat ( ) Cool ( ) Heat/Cool ( ) Night Setback ( )

Construction Data

Windows ____
Doors ____
Walls ____
Roof ____
Ceiling ____
Floor ____
Partitions ____
Basement Walls ____
Ground Slab ____

Figure 6-6 Example Load Calculation Summary

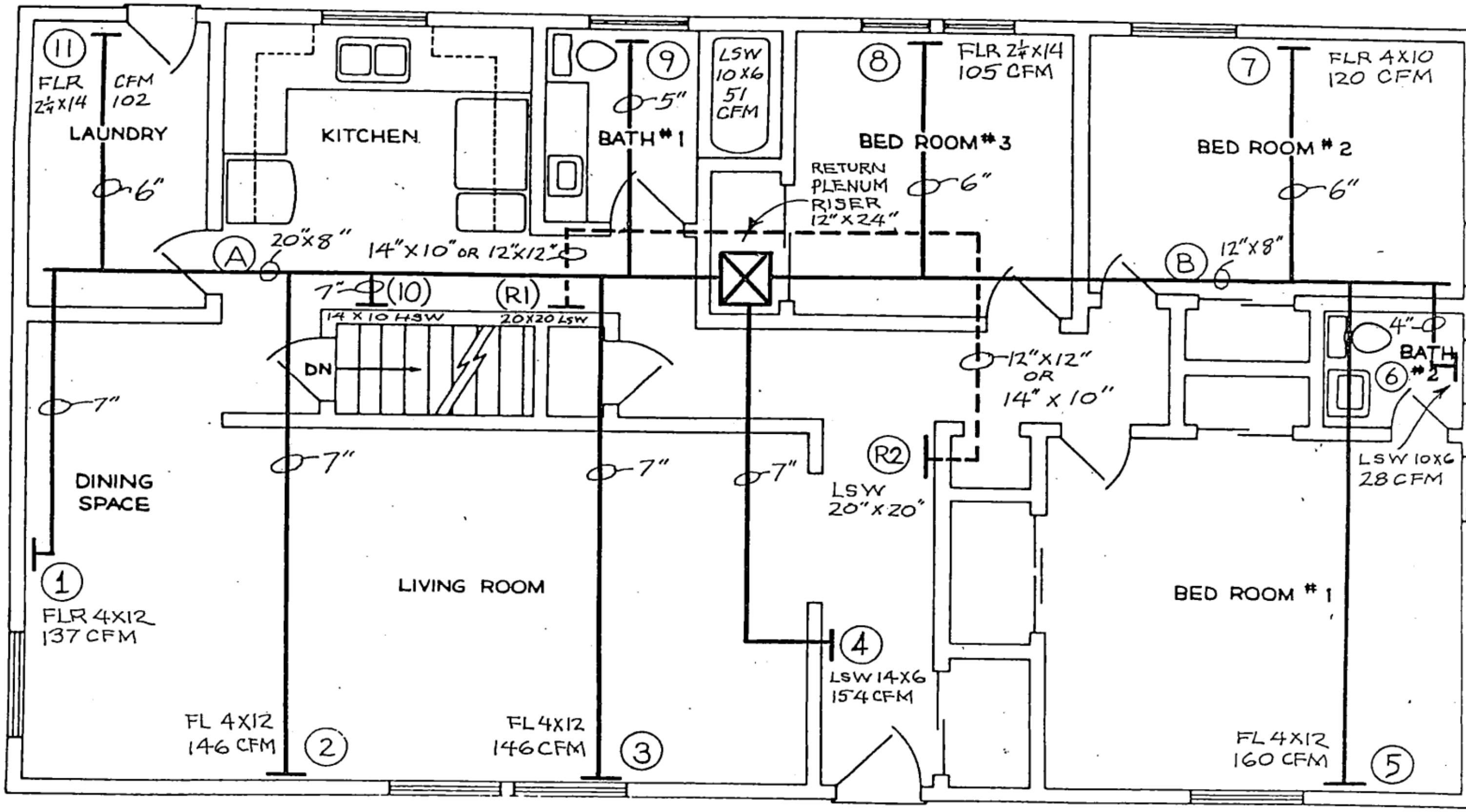
DETAILED CODE REFERENCES TO ACCA STANDARDS – 2009

Code Body	Code	ACCA Reference	Code Statement
International Association of Plumbing and Mechanical Officials	Uniform Mechanical Code	{**2015 UMC** §601.2} [**Manual D** Residential Duct Systems] {**2015 UMC** §601.2} [**Manual Q** Low Pressure Low Velocity Duct Systems Design] {**2009 UMC** §1106.1} [**Manual J** Residential Load Calculation] {**2009 UMC** §1106.1} [**Manual N** Commercial Load Calculations]	**601.2 Sizing Requirements (in Chapter 16 – DUCT SYSTEMS):** Duct systems used with blower-type equipment that are portions of a heating, cooling, absorption, evaporative cooling, or outdoor-air ventilation system shall be sized in accordance with Chapter 17, or by other approved methods. **1106.1 Human Comfort (in Chapter 11 – REFRIGERATION):** … Cooling equipment used for human comfort in dwelling units shall be sized to satisfy the calculated loads determined in accordance with the reference standards in Chapter 17 or other approved methods. **Chapter 17 Referenced Standards | Table 1701.1 Referenced Standards** - ACCA Manual D-2002 - ACCA Manual J-2003 - ACCA Manual N-2008 - ACCA Manual Q-2003
International Code Council	International Residential Code	{**2009 IRC** §M1401.3} [**Manual J** Residential Load Calculation] {**2009 IRC** §M1401.3} [**Manual S** Residential Equipment Selection] {**2009 IRC** §M1601.1 and§M1602.2 } [**Manual D** Residential Duct Systems]	**M1401.3 Equipment and appliance sizing.** Heating and cooling equipment and appliances shall be sized in accordance with **ACCA Manual S** based on building loads calculated in accordance with **ACCA Manual J** or other approved heating and cooling calculation methodologies. **M1601.1 Duct design.** Duct systems serving heating, cooling and ventilation equipment shall be installed in accordance with the provisions of this section and **ACCA Manual D**, the appliance manufacturer's installation instructions or other approved methods. **M1602.2 Return air openings.** Outdoor and return air for a forced-air heating or cooling system shall not be taken from the following locations: … 3. A room or space, the volume of which is less than 25 percent of the entire volume served by the system. Where connected by a permanent opening having an area sized in accordance with **ACCA Manual D**, adjoining rooms or spaces shall be considered as a single room or space for the purpose of determining the volume of the rooms or spaces. Exception. The minimum volume requirement shall not apply where the amount of return air taken from a room or space is less than or equal to the amount of supply air delivered to the room or space..
	International Energy Conservation Code	{**2009 IECC** §R403.6} [**Manual J** Residential Load Calculation] {**2009 IECC** §R403.6 } [**Manual S** Residential Equipment Selection]	**R403.6 Equipment sizing (Mandatory).** Heating and cooling equipment shall be sized in accordance with Section M1401.3 of the International Residential Code.
	International Mechanical Code	{**2009 IMC** §603.2} [**Manual D** Residential Duct Systems]	**603.2 Duct sizing.** Ducts installed within a single dwelling unit shall be sized in accordance with **ACCA Manual D** or other approved methods. Ducts installed within all other buildings shall be sized in accordance with the ASHRAE *Handbook of Fundamentals* or other equivalent computation procedure..

Orientation

Orientation

REGISTER, DIFFUSER AND GRILLE SIZES



MANUAL J HOUSE
EXTENDED PLENUM DUCT DESIGN

Figure 6.22

FINAL DUCT DESIGN FOR THE J-HOUSE

ACCA Air Conditioning Contractors of America

Residential Plans Examiner Review Form for HVAC System Design (Loads, Equipment, Ducts)

Form RPER 1.01 8 Mar 10

County, Town, Municipality, Jurisdiction

Header Information

Contractor ______________________

Mechanical License # ______________________

Building Plan # ______________________

Home Address (Street or Lot#, Block, Subdivision) ______________________

REQUIRED ATTACHMENTS[1]	ATTACHED	
Manual J1 Form (and supporting worksheets):	Yes ☐	No ☐
or MJ1AE Form[2] (and supporting worksheets):	Yes ☐	No ☐
OEM performance data (heating, cooling, blower):	Yes ☐	No ☐
Manual D Friction Rate Worksheet:	Yes ☐	No ☐
Duct distribution system sketch:	Yes ☐	No ☐

HVAC LOAD CALCULATION (UMC 1106.1)

Design Conditions

Winter Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Total heat loss ________ Btu

Summer Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Grains difference ________ Δ Gr @ ________ % Rh

Sensible heat gain ________ Btu

Latent heat gain ________ Btu

Total heat gain ________ Btu

Building Construction Information

Building

Orientation (Front door faces) ________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ________

Conditioned floor area ________ Sq Ft

Number of occupants ________

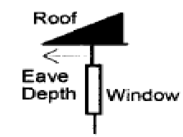
Windows

Eave overhang depth ________ Ft

Internal shade ________

Blinds, drapes, etc

Number of skylights ________



HVAC EQUIPMENT SELECTION

Heating Equipment Data

Equipment type ________

Furnace, Heat pump, Boiler, etc.

Model ________

Heating output capacity ________ Btu

Heat pumps - capacity at winter design outdoor conditions

Auxiliary heat output capacity ________ Btu

Cooling Equipment Data

Equipment type ________

Air Conditioner, Heat pump, etc

Model ________

Sensible cooling capacity ________ Btu

Latent cooling capacity ________ Btu

Total cooling capacity ________ Btu

Blower Data

Heating CFM ________ CFM

Cooling CFM ________ CFM

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (UMC 601.2)

Design airflow ________ CFM

External Static Pressure (ESP) ________ IWC

Component Pressure Losses (CPL) ________ IWC

Available Static Pressure (ASP) ________ IWC

ASP = ESP - CPL

Longest supply duct: ________ Ft

Longest return duct: ________ Ft

Total Effective Length (TEL) ________ Ft

Friction Rate: ________ IWC

Friction Rate = (ASP × 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ________

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ________

I declare the load calculation, equipment selection, and duct system design were rigorously performed based on the building plan listed above. I understand the claims made on these forms will be subject to review and verification.

Contractor's Printed Name ________ Date ________

Contractor's Signature ________

Reserved for use by County, Town, Municipality, or Authority having jurisdiction.

[1] The AHJ shall have the discretion to accept Required Attachments printed from approved ACCA software vendors, see list on page 2 of instructions.

[2] If abridged version of Manual J is used for load calculation, then verify residence meets requirements, see Abridged Edition Checklist on page 13 of instructions.

2009 International Residential Code

Verification Points

- **Manual "J"** has tables that contain specific values used in calculating individual loads.

- We will not go into the tables at this training but we will go over "Verification Points" to ensure code compliance.

- Using the ACCA Residential Plans Examiner Review Form, we will go over 40 points of compliance in the following sections:
- HVAC Load Calculation-Manual "J"
- HVAC Equipment Selection-Manual "S"
- HVAC Duct Distribution System Design Manual "D"

Residential Plans Examiner Review Form for HVAC System Design (Loads, Equipment, Ducts)

Form RPER 1.01
8 Mar 10

County, Town, Municipality, Jurisdiction
Header Information

Contractor ______
Mechanical License # ______
Building Plan # ______
Home Address (Street or Lot#, Block, Subdivision) ______

REQUIRED ATTACHMENTS[1]	ATTACHED	
Manual J1 Form (and supporting worksheets):	Yes ☐	No ☐
or MJ1AE Form[2] (and supporting worksheets):	Yes ☐	No ☐
OEM performance data (heating, cooling, blower):	Yes ☐	No ☐
Manual D Friction Rate Worksheet:	Yes ☐	No ☐
Duct distribution system sketch:	Yes ☐	No ☐

HVAC LOAD CALCULATION (IRC M1401.3)

Design Conditions

Winter Design Conditions

- Outdoor temperature 1. °F
- Indoor temperature 2. °F
- Total heat loss 14. Btu

Summer Design Conditions

- Outdoor temperature 3. °F
- Indoor temperature 4. °F
- Grains difference 5. Δ Gr @ 6. % Rh
- Sensible heat gain 15. Btu
- Latent heat gain 16. Btu
- Total heat gain 17. Btu

Building Construction Information

Building

- Orientation (Front door faces) 7.
  North, East, West, South, Northeast, Northwest, Southeast, Southwest
- Number of bedrooms 8.
- Conditioned floor area 9. Sq Ft
- Number of occupants 10.

Windows

- Eave overhang depth 11. Ft
- Internal shade 12.
  Blinds, drapes, etc
- Number of skylights 13.

Roof
Eave Depth
Window

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment Data

- Equipment type 18.
  Furnace, Heat pump, Boiler, etc.
- Model 19.
- Heating output capacity 20. Btu
  Heat pumps - capacity at winter design outdoor conditions
- Auxiliary heat output capacity 21. Btu

Cooling Equipment Data

- Equipment type 22.
  Air Conditioner, Heat pump, etc
- Model 23.
- Sensible cooling capacity 24. Btu
- Latent cooling capacity 25. Btu
- Total cooling capacity 26. Btu

Blower Data

- Heating CFM 27. CFM
- Cooling CFM 28. CFM

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

- Design airflow 29. CFM
- External Static Pressure (ESP) 30. IWC
- Component Pressure Losses (CPL) 31 IWC
- **Available Static Pressure (ASP)** 32. IWC
  ASP = ESP - CPL

- Longest supply duct: 33. Ft
- Longest return duct: 34. Ft
- **Total Effective Length (TEL)** 35. Ft
- **Friction Rate:** 36. IWC
  Friction Rate = (ASP × 100) ÷ TEL

Duct Materials Used (circle)
Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) 37.
Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) 38.

I declare the load calculation, equipment selection, and duct system design were rigorously performed based on the building plan listed above. I understand the claims made on these forms will be subject to review and verification.

Contractor's Printed Name 39. Date ______
Contractor's Signature 40.

Reserved for use by County, Town, Municipality, or Authority having jurisdiction.

[1] The AHJ shall have the discretion to accept Required Attachments printed from approved ACCA software vendors, see list on page 2 of instructions.
[2] If abridged version of Manual J is used for load calculation, then verify residence meets requirements, see Abridged Edition Checklist on page 13 of instructions.

HVAC LOAD CALCULATION (IRC M1401.3)

Design Conditions

Winter Design Conditions

Outdoor temperature ______ °F

Indoor temperature ______ °F

Total heat loss ______ Btu

Summer Design Conditions

Building Construction Information

Building

Orientation (Front door faces) ______

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ______

Conditioned floor area ______ Sq Ft

Line # 1 - Winter outside design temperature: Ensure this value comes from Manual “J” Table 1A or 1B. Manual J sec. A.5-1 “use of this set of conditions is mandatory, unless a code or regulations specifies another set of regulations”.

HVAC LOAD CALCULATION (IRC M1401.3)

Design Conditions

Winter Design Conditions

Outdoor temperature ______ °F

Indoor temperature ______ °F

Total heat loss ______ Btu

Summer Design Conditions

Building Construction Information

Building

Orientation (Front door faces) ______

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ______

Conditioned floor area ______ Sq Ft

Line # 2 - Winter Indoor Temperature: Should be 70 degrees: Manual J sec. A.5-3 “Heating and cooling load estimates shall be based on indoor design conditions… ANSI/ASHREA values which are 70 degrees.

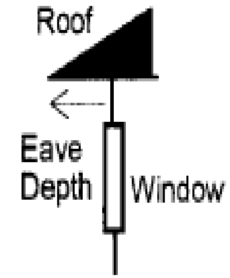
Summer Design Conditions

Outdoor temperature	______	°F
Indoor temperature	______	°F
Grains difference	____ ΔGr @ ____	% Rh
Sensible heat gain	______	Btu
Latent heat gain	______	Btu
Total heat gain	______	Btu

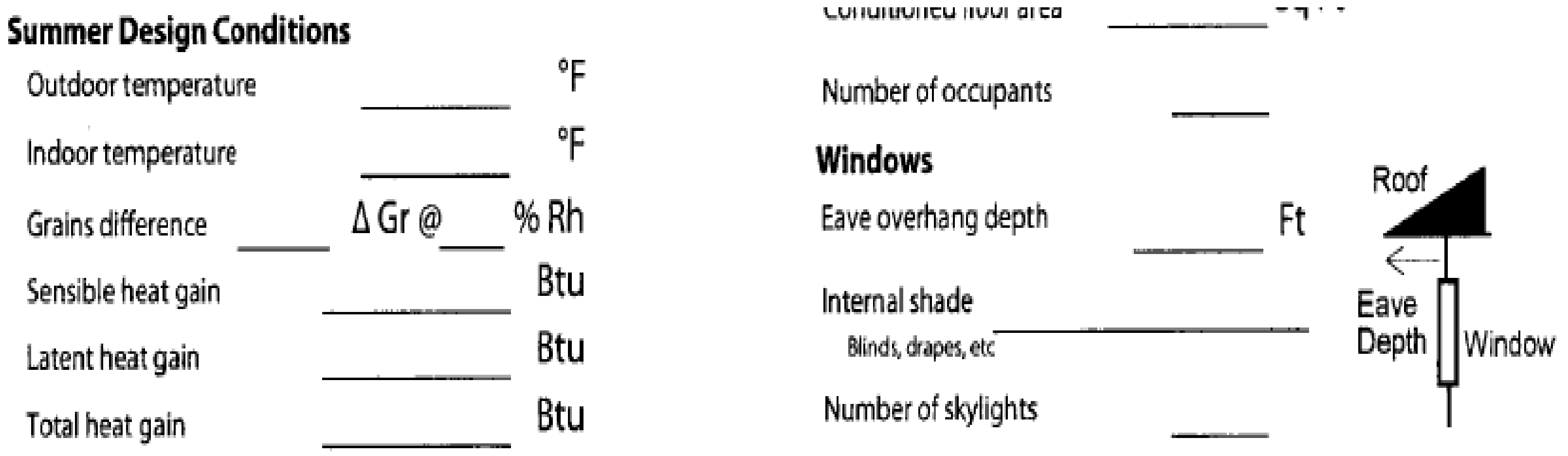
Conditioned floor area	______	sq ft
Number of occupants	____	

Windows

Eave overhang depth	______	Ft
Internal shade Blinds, drapes, etc	______	
Number of skylights	____	



Line # 3 - Summer Outdoor Temperature: Ensure this value comes from Manual "J" Table 1A or 1B "Use of this sect of conditions is mandatory, unless a code or regulation specifies another set of conditions".



Summer Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Grains difference _____ Δ Gr @ ___ % Rh

Sensible heat gain ________ Btu

Latent heat gain ________ Btu

Total heat gain ________ Btu

Number of occupants _____

Windows

Eave overhang depth ______ Ft

Internal shade ________

Blinds, drapes, etc

Number of skylights _____

Roof

Eave Depth

Window

Line # 4 - Summer Indoor Design Conditions: Manual "J" sec. A5-3 "Heating and cooling loads estimates shall be based on shall be based on indoor design conditions… ANSI/ ASHEA values of 75 degrees.

Summer Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Grains difference ______ Δ Gr @ ____ % Rh

Sensible heat gain ________ Btu

Latent heat gain ________ Btu

Total heat gain ________ Btu

Conditioned floor area ________ sq ft

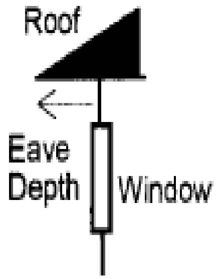
Number of occupants ______

Windows

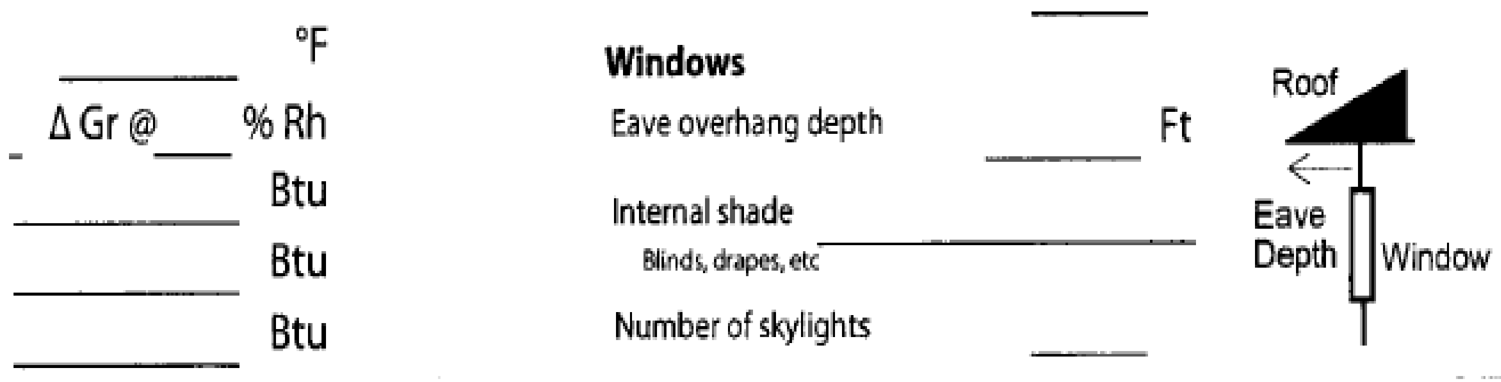
Eave overhang depth ______ Ft

Internal shade ____________
Blinds, drapes, etc

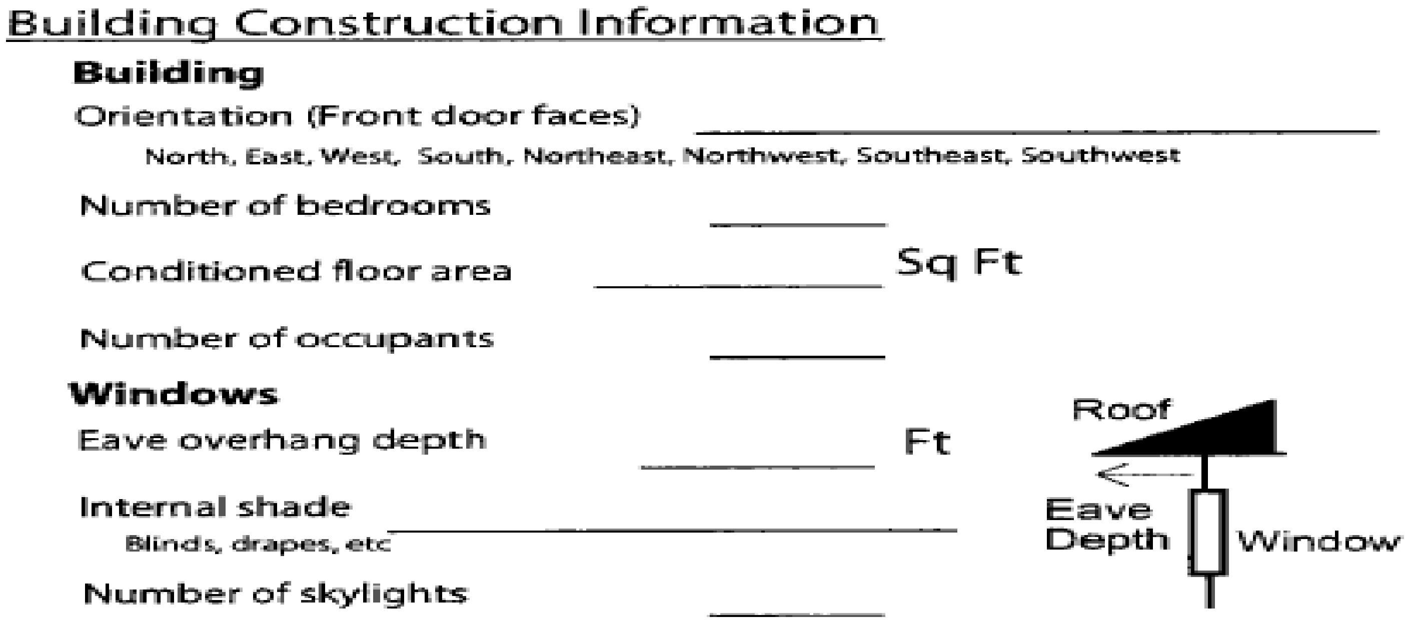
Number of skylights ______



Line # 5 - Summer Design Grains: Design Grains correspond to Relative Humidity, this value is to be determined by Manual "J" Table 1A.



Line # 6 - Relative Humidity: IECC Fig. 301.1 “Climate Zones”.


Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

Eave overhang depth __________ Ft

Internal shade ____________________

Blinds, drapes, etc

Number of skylights ________

Roof

Eave Depth

Window

Line # 7 - Orientation: Verification must be made to the structures orientation. Manual "J" sec. A5-4 Plans, Sketches and Notes states, "sketches and notes shall provide the following information. Sketches based on plan take-offs or field observations must have an arrow or directional rosette that points to the north".

Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

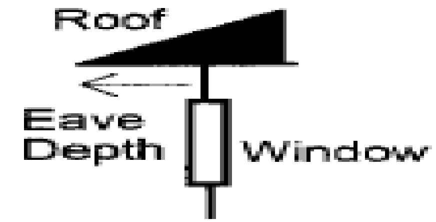
Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

Eave overhang depth ____________ Ft



Internal shade ____________________

Blinds, drapes, etc

Number of skylights ________

Line # 8 - Number of Bedrooms: Verify the number of bedrooms match the plan.

Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

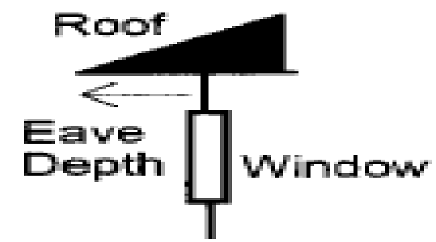
Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

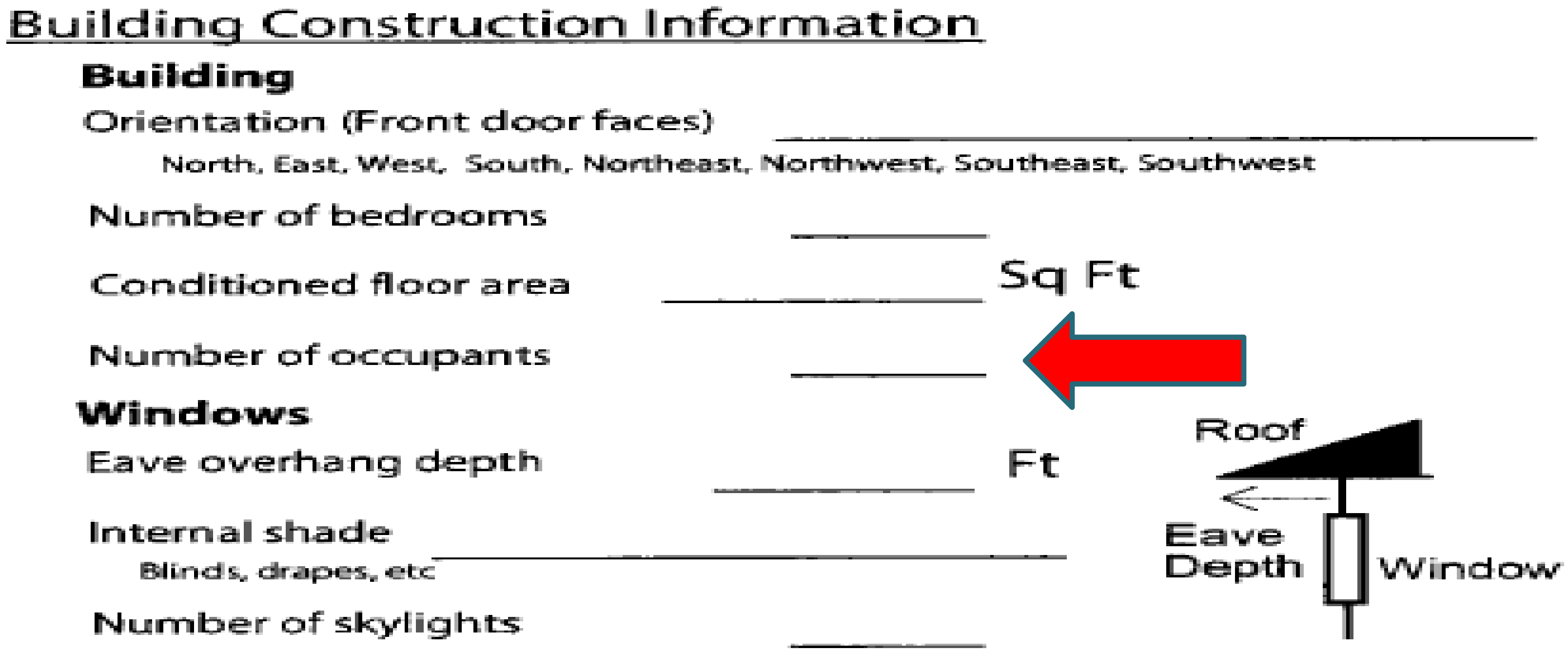
Eave overhang depth ________ Ft



Internal shade ____________________
Blinds, drapes, etc

Number of skylights ________

Line # 9 - Floor Area: Ensure the floor area matches the plans.



Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

Eave overhang depth ____________ Ft

Internal shade ____________________

Blinds, drapes, etc

Number of skylights ________

Line # 10 - Occupants: Ensure this value equals the number of bedrooms plus one. Manual “J” sec. 3.11 “occupants produce sensible and latent heat loads”.

Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

Eave overhang depth __________ Ft

Internal shade ____________________

Blinds, drapes, etc

Number of skylights ________

Line # 11 - Window overhangs: Manual "J" sec. 2-3 (Manual J Mandatory Requirements) Item # 6 "…overhangs adjustments shall be applied to all windows and glass doors. Including purpose-built day-lighting windows".

Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

Eave overhang depth __________ Ft

Internal shade ____________________
Blinds, drapes, etc

Number of skylights ________

Line # 12 - Window Internal Shade: Manual "J" sec. 2-3 (Mandatory Requirements) item # 7 "Take credit for internal shade (the default is a medium color blind with slats at 45 degrees, or the use of the actual device, this applies to all vertical glass, this does not apply to purpose-built day-light windows)" unless there is contrary evidence, HVAC system designers shall default to a "medium color blind with slats at 45 degrees".

Building Construction Information

Building

Orientation (Front door faces) ____________________

North, East, West, South, Northeast, Northwest, Southeast, Southwest

Number of bedrooms ________

Conditioned floor area ____________ Sq Ft

Number of occupants ________

Windows

Eave overhang depth __________ Ft

Internal shade ____________________

Blinds, drapes, etc

Number of skylights ________

Line # 13 - Number of Skylights: Skylights have a large impact on the heating and cooling load calculations. Ensure the number of skylights on the building plans are represented accurately.

HVAC LOAD CALCULATION (IRC M1401.3)

Design Conditions

Winter Design Conditions

Outdoor temperature	______________	°F
Indoor temperature	______________	°F
Total heat loss	______________	Btu

Summer Design Conditions

Outdoor temperature	______________	°F
Indoor temperature	______________	°F
Grains difference	________ Δ Gr @ ______	% Rh
Sensible heat gain	______________	Btu
Latent heat gain	______________	Btu
Total heat gain	______________	Btu

Line # 14 - Total Heat Loss: This value is used to select the heating system, you may wish to verify this value is the sum of all the individual loads.

Summer Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Grains difference _____ Δ Gr @ ___ % Rh

Sensible heat gain ________ Btu

Latent heat gain ________ Btu

Total heat gain ________ Btu

Conditioned floor area ________ sq ft

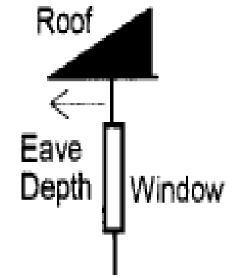
Number of occupants _____

Windows

Eave overhang depth ______ Ft

Internal shade ____________
Blinds, drapes, etc

Number of skylights _____



Line # 15 - Sensible Heat Gain: This value represents the amount of dry heat the cooling system must remove according to the calculations.

Summer Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Grains difference _____ Δ Gr @ ___ % Rh

Sensible heat gain ________ Btu

Latent heat gain ________ Btu

Total heat gain ________ Btu

Conditioned floor area ________ sq ft

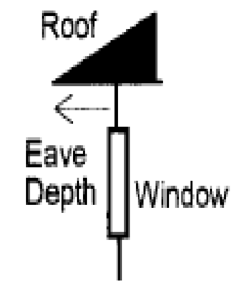
Number of occupants _____

Windows

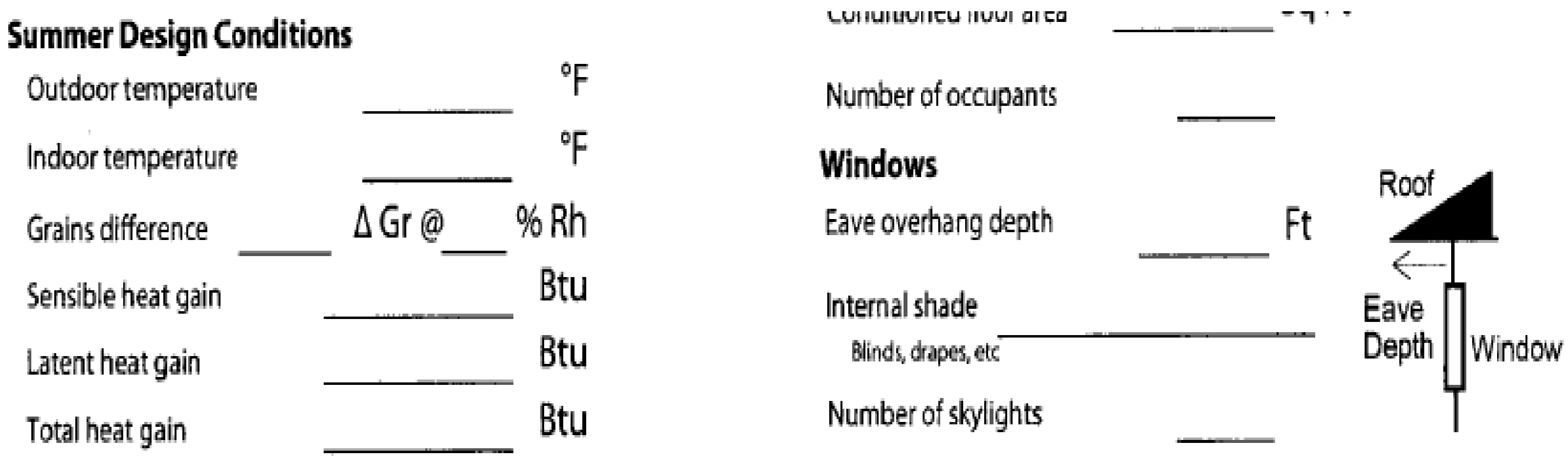
Eave overhang depth ______ Ft

Internal shade ________________
Blinds, drapes, etc

Number of skylights _____



Line # 16 - Latent Heat Gain: This value represents the amount of moist heat (humid) the cooling system must remove according to the calculations.



Summer Design Conditions

Outdoor temperature ________ °F

Indoor temperature ________ °F

Grains difference _____ ΔGr @ ___ % Rh

Sensible heat gain ________ Btu

Latent heat gain ________ Btu

Total heat gain ________ Btu

Number of occupants _____

Windows

Eave overhang depth ______ Ft

Internal shade ____________
Blinds, drapes, etc

Number of skylights _____

Line # 17 - Total Heat Gain: This value is used to size the cooling system; the total cooling capacity shall equal the sensible and latent heat gains (lines 15 & 16 must equal line 17).

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment Data		Cooling Equipment Data		Blower Data	
Equipment type Furnace, Heat pump, Boiler, etc.	________	Equipment type Air Conditioner, Heat pump, etc	________	Heating CFM	________ CFM
Model	________	Model	________	Cooling CFM	________ CFM
Heating output capacity Heat pumps - capacity at winter design outdoor conditions	________ Btu	Sensible cooling capacity	________ Btu		
		Latent cooling capacity	________ Btu		
Auxiliary heat output capacity	________ Btu	Total cooling capacity	________ Btu		

Line # 18 - Equipment Type: A description of the type of heating source used: furnace, Boiler…

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment Data		Cooling Equipment Data		Blower Data	
Equipment type Furnace, Heat pump, Boiler, etc.	______	Equipment type Air Conditioner, Heat pump, etc	______	Heating CFM	______ CFM
Model	______	Model	______	Cooling CFM	______ CFM
Heating output capacity Heat pumps - capacity at winter design outdoor conditions	______ Btu	Sensible cooling capacity	______ Btu		
		Latent cooling capacity	______ Btu		
Auxiliary heat output capacity	______ Btu	Total cooling capacity	______ Btu		

Line # 19 - Model of Heating Equipment: List the model(s) of heating equipment (should be verified).

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment Data		Cooling Equipment Data		Blower Data	
Equipment type Furnace, Heat pump, Boiler, etc.	______	Equipment type Air Conditioner, Heat pump, etc	______	Heating CFM	______ CFM
Model	______	Model	______	Cooling CFM	______ CFM
Heating output capacity Heat pumps - capacity at winter design outdoor conditions	______ Btu	Sensible cooling capacity	______ Btu		
		Latent cooling capacity	______ Btu		
Auxiliary heat output capacity	______ Btu	Total cooling capacity	______ Btu		

Line # 20 - Heating Output Capacity: The amount of maximum **OUTPUT** heating capacity available from the heating unit shall be equal to, but not to exceed 140% of heat loss value found on Line 14.

HVAC EQUIPMENT SELECTION (IRC M1401.3)

Heating Equipment Data		Cooling Equipment Data		Blower Data	
Equipment type (Furnace, Heat pump, Boiler, etc.)	______	Equipment type (Air Conditioner, Heat pump, etc)	______	Heating CFM	______ CFM
Model	______	Model	______	Cooling CFM	______ CFM
Heating output capacity (Heat pumps - capacity at winter design outdoor conditions)	______ Btu	Sensible cooling capacity	______ Btu		
		Latent cooling capacity	______ Btu		
Auxiliary heat output capacity	______ Btu	Total cooling capacity	______ Btu		

Line # 21 – Auxiliary Heating Output Capacity: If a heat pump is to be used supplemental heat may be required, consult the designer for justification.

Cooling Equipment Data

Equipment type ______________________
Air Conditioner, Heat pump, etc

Model ______________________

Sensible cooling capacity __________ Btu

Latent cooling capacity __________ Btu

Total cooling capacity __________ Btu

Blower Data

Heating CFM __________ CFM

Cooling CFM __________ CFM

Line # 22 – Cooling Equipment Type: A description of the cooling equipment that will be installed: air conditioner, heat pump, etc …

Cooling Equipment Data

Equipment type ______________________
Air Conditioner, Heat pump, etc

Model ______________________

Sensible cooling capacity __________ Btu

Latent cooling capacity __________ Btu

Total cooling capacity __________ Btu

Blower Data

Heating CFM __________ CFM

Cooling CFM __________ CFM

Line # 23 – Model of Cooling Equipment: The model of cooling equipment to be installed.

Cooling Equipment Data

Equipment type ____________________

Air Conditioner, Heat pump, etc

Model ____________________

Sensible cooling capacity ____________ Btu

Latent cooling capacity ____________ Btu

Total cooling capacity ____________ Btu

Blower Data

Heating CFM ____________ CFM

Cooling CFM ____________ CFM

Line # 24 - Sensible Cooling Capacity: The sensible cooling capacity of the equipment should satisfy the sensible cooling requirements on line 15.

Cooling Equipment Data

Equipment type ____________________
Air Conditioner, Heat pump, etc

Model ____________________

Sensible cooling capacity ____________ Btu

Latent cooling capacity ____________ Btu

Total cooling capacity ____________ Btu

Blower Data

Heating CFM ____________ CFM

Cooling CFM ____________ CFM

Line # 25 - Latent Cooling Capacity: Latent cooling capacity is rarely listed on the manufacturer's performance data plate. However, it can be derived from subtracting the sensible cooling(dry) line 24 from the total cooling capacity line 26.

Cooling Equipment Data			Blower Data	
Equipment type Air Conditioner, Heat pump, etc			Heating CFM	CFM
Model			Cooling CFM	CFM
Sensible cooling capacity		Btu		
Latent cooling capacity		Btu		
Total cooling capacity		Btu		

Line # 26 - Total Cooling Capacity: The amount of maximum cooling capacity available from the equipment shall not exceed 115% of heat gain value of line 17.

Cooling Equipment Data

Equipment type ____________________
Air Conditioner, Heat pump, etc

Model ____________________

Sensible cooling capacity __________ Btu

Latent cooling capacity __________ Btu

Total cooling capacity __________ Btu

Blower Data

Heating CFM __________ CFM

Cooling CFM __________ CFM

Line # 27 - Heating CFM (*cubic feet per minute*): The volume of air required to deliver the heating BTUs for the structure.

Cooling Equipment Data

Equipment type ____________________

Air Conditioner, Heat pump, etc

Model ____________________

Sensible cooling capacity __________ Btu

Latent cooling capacity __________ Btu

Total cooling capacity __________ Btu

Blower Data

Heating CFM __________ CFM

Cooling CFM __________ CFM

Line # 28 - Cooling CFM: The volume of air to deliver total cooling capacity to the structure.

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

Design airflow	______	CFM	Longest supply duct:	______	Ft	Duct Materials Used (circle) Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ______
External Static Pressure (ESP)	______	IWC	Longest return duct:	______	Ft	
Component Pressure Losses (CPL)	______	IWC	**Total Effective Length (TEL)**	______	Ft	Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ______
Available Static Pressure (ASP) ASP = ESP - CPL	______	IWC	**Friction Rate:** Friction Rate = (ASP x 100) ÷ TEL	______	IWC	

Line # 29 - Design Air Flow: The volume of air delivered by a piece of equipment at a given fan speed, voltage, and amount of pressure (the larger of heating or cooling CFM line 27 and 28).

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

Design airflow ______ CFM	Longest supply duct: ______ Ft	Duct Materials Used (circle)
External Static Pressure (ESP) ______ IWC	Longest return duct: ______ Ft	Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ______
Component Pressure Losses (CPL) ______ IWC	**Total Effective Length (TEL)** ______ Ft	
Available Static Pressure (ASP) ______ IWC	**Friction Rate:** ______ IWC	Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ______
ASP = ESP - CPL	Friction Rate = (ASP x 100) ÷ TEL	

Line # 30 - Static pressure: The static pressure is the amount of pressure in inches of water column the appliance's blower can push through and still deliver the stated volume of air in line 29.

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

Design airflow	______	CFM	Longest supply duct:	______	Ft	Duct Materials Used (circle) Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)
External Static Pressure (ESP)	______	IWC	Longest return duct:	______	Ft	
Component Pressure Losses (CPL)	______	IWC	**Total Effective Length (TEL)**	______	Ft	______
Available Static Pressure (ASP)	______	IWC	**Friction Rate:**	______	IWC	Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)
ASP = ESP - CPL			Friction Rate = (ASP x 100) ÷ TEL			______

Line # 31 - Component Pressure Loss: The total resistance or pressure created by accessories like filters, refrigeration coils, grills, registers, dampers…

HVAC DUCT DISTRIBUTION SYSTEM DESIGN (IRC M1601.1)

Design airflow	______	CFM	Longest supply duct:	______	Ft	Duct Materials Used (circle) Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ______
External Static Pressure (ESP)	______	IWC	Longest return duct:	______	Ft	
Component Pressure Losses (CPL)	______	IWC	**Total Effective Length (TEL)**	______	Ft	Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify) ______
Available Static Pressure (ASP) ASP = ESP - CPL	______	IWC	**Friction Rate:** Friction Rate = (ASP x 100) ÷ TEL	______	IWC	

Line # 32 - Available Static Pressure *(ASP)*: The difference between the static pressure (line 30) and the component pressure loss (line 31).

Longest supply duct: ________ Ft

Longest return duct: ________ Ft

Total Effective Length (TEL) ________ Ft

Friction Rate: ________ IWC

Friction Rate = (ASP x 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Line # 33 - Longest Supply duct: The effective length of the longest supply duct run. Different duct fittings create differing amounts of resistance. The calculation is based on the resistance factor of a straight run in feet.

Longest supply duct: ______ Ft

Longest return duct: ______ Ft

Total Effective Length (TEL) ______ Ft

Friction Rate: ______ IWC

Friction Rate = (ASP x 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Line # 34 - Longest Return Duct: Same properties as line 33 but applies to the return ducts.

Longest supply duct: ________ Ft

Longest return duct: ________ Ft

Total Effective Length (TEL) ________ Ft

Friction Rate: ________ IWC

Friction Rate = (ASP x 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Line # 35 - Total Effective Length: The sum total of supply and return effective lengths add line 33 and 34.

Longest supply duct: ______ Ft

Longest return duct: ______ Ft

Total Effective Length (TEL) ______ Ft

Friction Rate: ______ IWC

Friction Rate = (ASP x 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

______

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

______

Line # 36 - Friction Rate: (ASPx100) divided by TEL = FR) WHAT! Line 32 multiply by 100 then divide by line 35 this will give the friction loss. Friction loss must be greater than .06 IWC. and less than 0.18 IWC (yes another "rule of thumb").

Longest supply duct: ______ Ft

Longest return duct: ______ Ft

Total Effective Length (TEL) ______ Ft

Friction Rate: ______ IWC

Friction Rate = (ASP x 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

____

Line # 37 - Duct Material used: Have the designer to justify the material used and the calculated friction properties.

Longest supply duct: ______ Ft

Longest return duct: ______ Ft

Total Effective Length (TEL) ______ Ft

Friction Rate: ______ IWC

Friction Rate = (ASP x 100) ÷ TEL

Duct Materials Used (circle)

Trunk Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

______

Branch Duct: Duct board, Flex, Sheet metal, Lined sheet metal, Other (specify)

______

Line # 38 - Branch Duct: Specify Type - must verify.

I declare the load calculation, equipment selection, and duct system design were rigorously performed based on the building plan listed above, I understand the claims made on these forms will be subject to review and verification.

Contractor's Printed Name ______________________ Date ____________

Contractor's Signature ______________________________

Reserved for use by County, Town, Municipality, or Authority having jurisdiction.

[1] The AHJ shall have the discretion to accept Required Attachments printed from approved ACCA software vendors, see list on page 2 of instructions.

[2] If abridged version of Manual J is used for load calculation, then verify residence meets requirements, see Abridged Edition Checklist on page 13 of instructions.

Line # 39 - Contractor's printed name.

I declare the load calculation, equipment selection, and duct system design were rigorously performed based on the building plan listed above, I understand the claims made on these forms will be subject to review and verification.

Contractor's Printed Name ______________________ Date ____________

Contractor's Signature ______________________________________

Reserved for use by County, Town, Municipality, or Authority having jurisdiction.

[1] The AHJ shall have the discretion to accept Required Attachments printed from approved ACCA software vendors, see list on page 2 of instructions.

[2] If abridged version of Manual J is used for load calculation, then verify residence meets requirements, see Abridged Edition Checklist on page 13 of instructions.

Line # 40 - *Contractor's Signature.*

2009 International Residential Code

- **HVAC Load Calculation -**
- **Line # 1- Winter outside design temperature:** Ensure this value comes from Manual "J" Table 1A or 1B. Manual J sec. A.5-1 "use of this set of conditions is mandatory, unless a code or regulations specifies another set of regulations".
- **Line # 2- Winter Indoor Temperature: Should be 70 degrees.** Manual J sec. A.5-3 "Heating and cooling load estimates shall be based on indoor design conditions… ANSI/ASHREA values which are 70 degrees.
- **Line # 3- Summer Outdoor Temperature:** Ensure this value comes from Manual "J" Table 1A or 1B "Use of this sect of conditions is mandatory, unless a code or regulation specifies another set of conditions".

2009 International Residential Code

- **HVAC Load Calculation –**
- **Line # 4 - Summer Indoor Design Conditions:** Manual "J" sec. A5-3 "Heating and cooling loads estimates shall be based on shall be based on indoor design conditions… ANSI/ASHEA values of 75 degrees.
- **Line # 5 - Summer Design Grains:** Design Grains correspond to Relative Humidity, this value is to be determined by Manual "J" Table 1A.
- **Line # 6 - Relative Humidity:** IECC Fig. 301.1 "Climate Zones".
- **Line # 7 - Orientation:** Verification must be made to the structures orientation. Manual "J" sec. A5-4 Plans, Sketches and Notes states, "sketches and notes shall provide the following information. Sketches based on plan take-offs or field observations must have an arrow or directional [illegible]e that points to the north".

2009 International Residential Code

- **HVAC Load Calculation –**
- **Line # 8 - Number of Bedrooms:** Verify the number of bedrooms match the plan.
- **Line # 9 - Floor Area:** Ensure the floor area matches the plans.
- **Line # 10 - Occupants:** Ensure this value equals the number of bedrooms plus one. Manual "J" sec. 3.11 "occupants produce sensible and latent heat loads".
- **Line # 11-Window overhangs:** Manual "J" sec. 2-3 (Manual J Mandatory Requirements) Item # 6 "…overhangs adjustments shall be applied to all windows and glass doors. Including purpose-built day-lighting windows".

2009 International Residential Code

- **HVAC Load Calculation –**
- **Line # 12 - Window Internal Shade:** Manual "J" sec. 2-3 (Mandatory Requirements) item # 7 "Take credit for internal shade (the default is a medium color blind with slats at 45 degrees, or the use of the actual device, this applies to all vertical glass, this does not apply to purpose-built day-light windows)" unless there is contrary evidence, HVAC system designers shall default to a "medium color blind with slats at 45 degrees".
- **Line # 13 - Number of Skylights:** Skylights have a large impact on the heating and cooling load calculations. Ensure the number of skylights on the building plans are represented accurately.

2009 International Residential Code

- **HVAC Load Calculation –**
- **Line # 14 - Total Heat Loss:** This value is used to select the heating system, you may wish to verify this value is the sum of all the individual loads.
- **Line # 15 - Sensible Heat Gain:** This value represents the amount of dry heat the cooling system must remove according to the calculations.
- **Line # 16 - Latent Heat Gain:** This value represents the amount of moist heat (humid) the cooling system must remove according to the calculations.
- **Line # 17 - Total Heat Gain:** This value is used to size the cooling system; the total cooling capacity shall equal the sensible and latent heat gains (lines 15 & 16 must equal line 17).
- **Manual "S" HVAC Equipment Selection.**

2009 International Residential Code

- **HVAC Load Calculation –**
- **Line # 18 - Equipment Type:** A description of the type of heating source used: furnace, Boiler…
- **Line # 19 - Model of Heating Equipment:** List the model(s) of heating equipment (should be verified)
- **Line # 20 - Heating Output Capacity:** The amount of maximum OUTPUT heating capacity available from the heating unit shall be equal to, but not to exceed 140% of heat loss value found on Line 14.
- **Line # 21 – Auxiliary Heating Output Capacity:** If a heat pump is to be used supplemental heat may be required, consult the designer for justification.

2009 International Residential Code

- **HVAC Load Calculation –**
- **Line # 22 – Cooling Equipment Type:** A description of the cooling equipment that will be installed: air conditioner, heat pump, etc …
- **Line # 23 – Model of Cooling Equipment:** The model of cooling equipment to be installed.
- **Line # 24 - Sensible Cooling Capacity:** The sensible cooling capacity of the equipment should satisfy the sensible cooling requirements on line 15.
- **Line # 25 - Latent Cooling Capacity:** Latent cooling capacity is rarely listed on the manufacturer's performance data plate. However, it can be derived from subtracting the sensible cooling(dry) line 24 from the total cooling capacity line 26.
- **Line # 26 - Total Cooling Capacity:** The amount of maximum cooling capacity available from the equipment shall not exceed 115% of heat gain value of line 17.

2009 International Residential Code

- **HVAC Load Calculation –**
- **Manual "D" HVAC Duct Distribution system Design**
- **Line # 27 - Heating CFM** *(cubic feet per minute)***:** The volume of air required to deliver the heating BTUs for the structure.
- **Line # 28 - Cooling CFM:** The volume of air to deliver total cooling capacity to the structure.
- **Line # 29 - Design Air Flow:** The volume of air delivered by a piece of equipment at a given fan speed, voltage, and amount of pressure (the larger of heating or cooling CFM line 27 and 28).
- **Line # 30 - Static pressure:** The static pressure is the amount of pressure in inches of water column the appliance's blower can push through and still deliver the stated volume of air in line 29.

2009 International Residential Code

- **Line # 31 - Component Pressure Loss:** The total resistance or pressure created by accessories like filters, refrigeration coils, grills, registers, dampers…
- **Line # 32 - Available Static Pressure *(ASP)*:** The difference between the static pressure (line 30) and the component pressure loss (line 31).
- **Line # 33 - Longest Supply duct:** The effective length of the longest supply duct run. Different duct fittings create differing amounts of resistance. The calculation is based on the resistance factor of a straight run in feet.
- **Line # 34 - Longest Return Duct:** same properties as line 33 but applies to the return ducts.

2009 International Residential Code

- **Line # 35 - Total Effective Length:** The sum total of supply and return effective lengths add line 33 and 34.
- **Line # 36 - Friction Rate** (ASPx100) divided by TEL = FR) WHAT! Line 32 multiply by 100 then divide by line 35 this will give the friction loss. Friction loss must be greater than .06 IWC. and less than 0.18 IWC (yes another "rule of thumb").
- **Line # 37 - Duct Material used.** Have the designer to justify the material used and the calculated friction properties.
- **Line # 38 - Branch Duct:** specify Type must verify.
- **Line # 39 - Contractor's printed name.**
- **Line # 40 - *Contractor's Signature.***

2009 International Residential Code

- If you follow the 40 verification points you will notice they build and reference each components, I found it is very difficult to doctor or fudge these numbers if you follow the "rules of thumb" and the residential plans examiner review form for HVAC system design.

- In addition to this form you should be receiving a full set of plans and calculations including the Manual "J" J-1 form, OEM performance date for heating, cooling and blower… in compliance with Manual "S" equipment selection, Manual "D" friction rate worksheet and a duct distribution system sketch.

Department of Public Safety

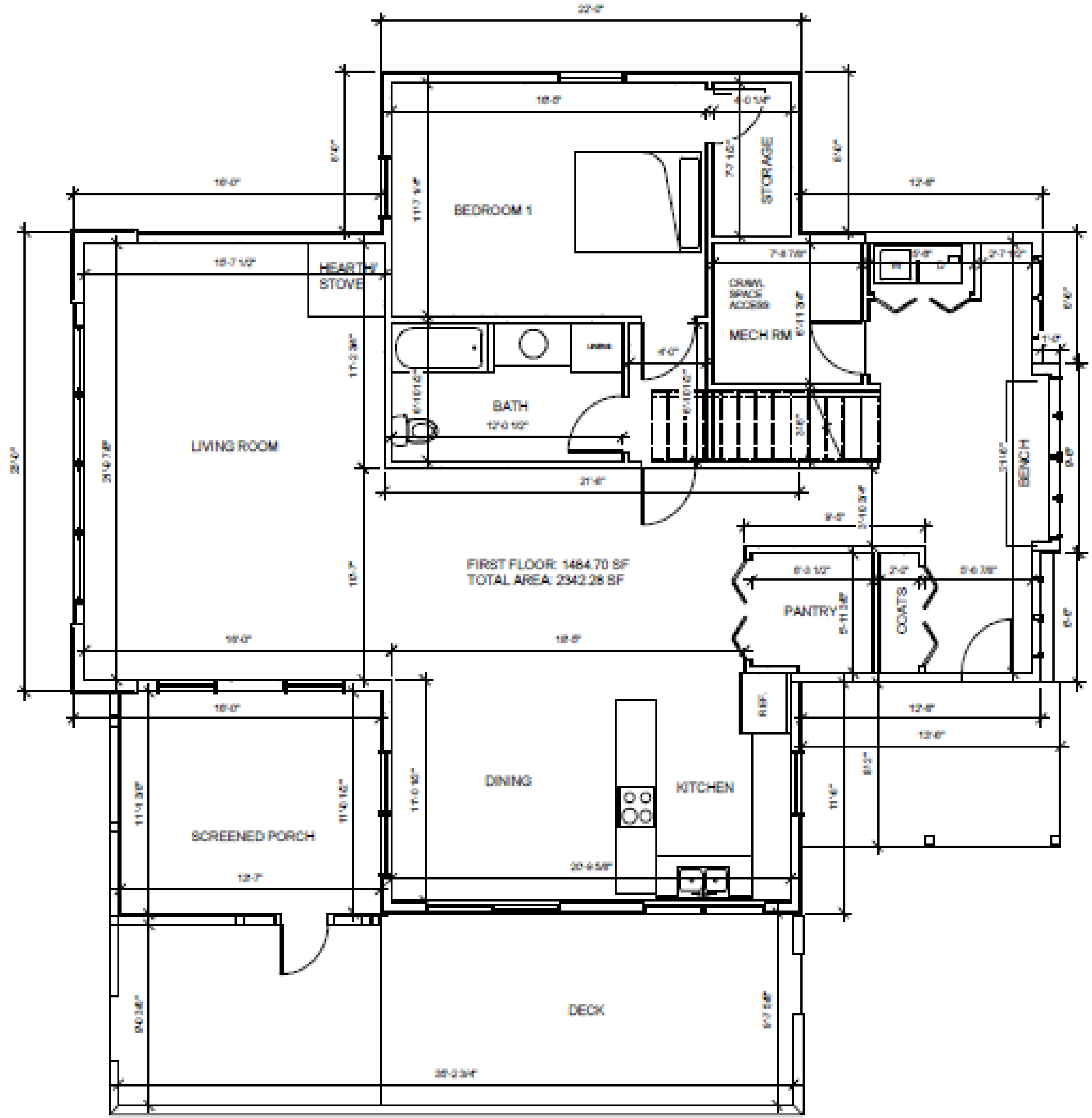
Introduction to Residential HVAC System Basics

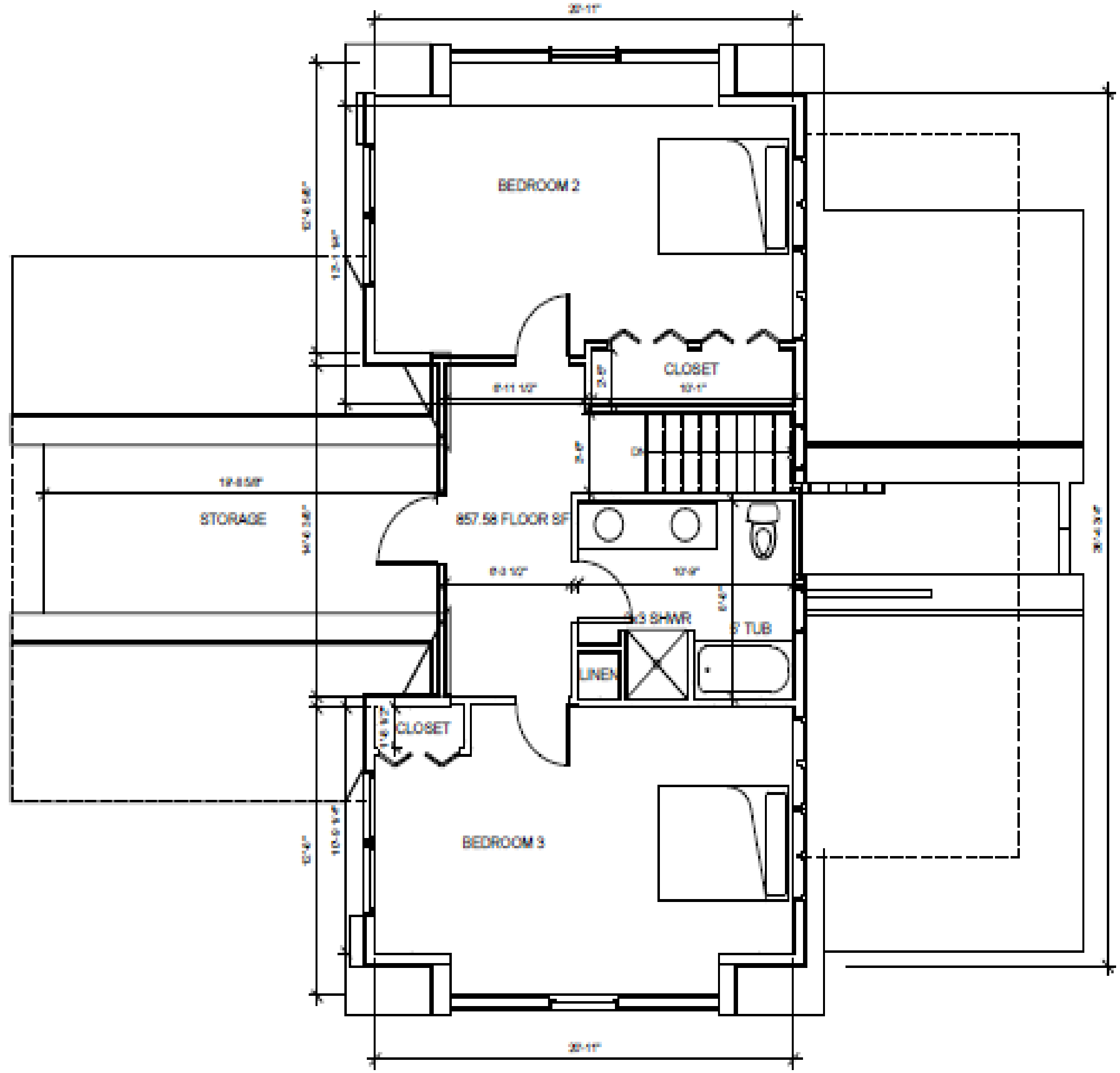
That completes our seminar on Introduction to Residential HVAC.

THANK YOU!

Harold Leaming

DPS Building Inspector


BEDROOM 1
STORAGE
HEARTH/
STOVE
LIVING ROOM
BATH
CRAWL
SPACE
ACCESS
MECH RM
BENCH
FIRST FLOOR: 1484.70 SF
TOTAL AREA: 2342.28 SF
PANTRY
COATS
REF.
DINING
KITCHEN
SCREENED PORCH
DECK


BEDROOM 2
CLOSET
STORAGE
857.58 FLOOR SF
LINEN
CLOSET
BEDROOM 3