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ZONING DUCT DESIGN GUIDE

For Mechanical System Designers

Version 1.0

Developed by the Innovation and Energy Technology Sector's CanmetENERGY housing researchers and LEEP (Local Energy Efficiency Partnerships) team.

Canada

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OVERVIEW OF THE ZONING DESIGN STEPS

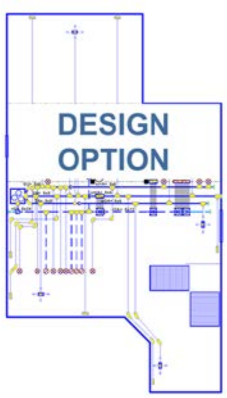
The steps in this design process are:

- **STEP 1:** Recommended Prerequisites for Use
- **STEP 2:** Determine Heating and Cooling Loads
- **STEP 3:** Define Heating and Cooling Equipment Requirements
- **STEP 4:** Specify the Return-Air Ducting Requirements
- **STEP 5:** Specify the Supply-Air Ducting Requirements
- **STEP 6:** Specify Thermostat Requirements
- **STEP 7:** Prepare Installation and Commissioning Notes for the HVAC Installer and Technician

Watch for these graphics that indicate:

Required Builder Inputs

Figure 1: Required builder decisions are highlighted with a "Zoning Checklist" icon to draw attention to key feature selections that will provide the starting point for developing your detailed HVAC system design.



Design Options for Improved Air Distribution & Effectiveness

Figure 2: Suggested duct design options are introduced using a "DESIGN OPTION" icon. These alternative design approaches can simplify the overall air distribution design and improve the air distribution effectiveness.

STEP 1: RECOMMENDED PREREQUISITES

This ***Zoning Duct Design Guide*** has been developed in an effort to provide mechanical designers with a generic approach for designing zoned ducting systems that are compatible with most forced-air equipment. It builds on design information communicated in the **Zoning Checklist** for Builders.

1.1 Experience

The ***Zoning Duct Design Guide*** is intended for use by experienced professional mechanical designers with Heating, Refrigeration and Air Conditioning Institute (HRAI) or equivalent certification, as listed on the HRAI website. Refer to Appendix C for reference to the HRAI Certified Installers and Designers Listing. The mechanical designer should have at least Residential Heat Loss & Heat Gain (RHLG) and Residential Air Systems Design (RASD) designation.

1.2 Zoning Checklist for Builders

The starting point for this ***Zoning Duct Design Guide*** is a completed **Zoning Checklist for Builders** that has been developed in coordination with your builder. The intent of the checklist is to summarize the “key features” of a zoned HVAC system.

If the **Zoning Checklist for Builders has not yet been completed**, please contact your builder and develop it together. You can help them select the options presented in the industry-tested **Zoning Decision Guide for Builders** to help them choose the most beneficial and appropriate zoning approach as the starting point for your zoned duct designs.

Refer to Appendix C for reference to the Zoning Decision Guide for Builders. It can be downloaded at no charge from the web by searching for the name of the publication: **Natural Resources Canada Zoning Decision Guide for Builders.**

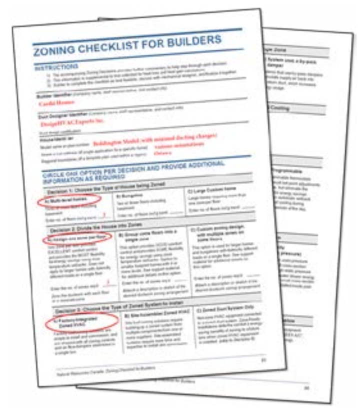

ZONING CHECKLIST FOR BUILDERS

Figure 1-1: Example of a **Zoning Checklist** for Builders which is available on-line as part of the “Zoning Decision Guide for Builders”

Mechanical Designers are encouraged to refer to the **Zoning Decision Guide for Builders** for additional background information on centrally-zoned, forced-air HVAC systems, including complete descriptions of all “key feature” options that are summarized in the **Zoning Checklist for Builders**.

The **Zoning Decision Guide for Builders** also provides information on:

- Why zoning is being used to address the changing needs of today’s housing;
- Zoning for improved comfort and energy management; and,
- Recent advances that making zoning more effective and more affordable.

1.3 Scope of the *Zoning Duct Design Guide*

The focus of this Guide is on zoned forced-air duct designs targeted primarily at tract housing developments, and it:

- Applies only to centrally zoned forced air systems including:
  a. Factory-integrated zoned equipment that is split into separate zone supplies within the air handling equipment, or
  b. Site-assembled zoned equipment that is divided at the plenum into separate zone trunks close to the air handling equipment.
- Applies to duct designs using two (2) to four (4) zone supply trunks (see Section 2.4);
- Applies to zoned duct designs implemented with HRAI-compliant low velocity duct technology (e.g., total external static pressure of less than or equal to 0.5-in w.g. or 125 Pa);
- May be used to inform duct designs implemented with medium-velocity and high-velocity duct technologies (e.g., total external static pressure of greater than 0.5-in w.g. or 125 Pa).
- Applies to fully zoned systems with “roughly equal” zone heating loads
- Emphasizes zoning options most common in tract housing such as floor-by-floor zoning;
- Emphasizes the use of fully zoned systems with automated zoning dampers that incorporate controls to provide the full benefit of zoning;
- Excludes specialized zoning elements such as home theatres, indoor pool areas and radiant-slab-heated zones.

Upon completing Step 1, you will have:

☐ Consulted with your builder and obtained or completed a “ **Zoning Checklist**”, which summarizes the “key features” of a zoned HVAC system, as the starting point for your design.

STEP 2: DETERMINE HEATING AND COOLING LOADS

2.1 Gather house plans & detailed envelope specifications

The mechanical designer should gather from the builder a complete set of construction schematics and other specifications for the particular house model being considered as input to the heat loss calculations and the HVAC system design processes. Areas of particular interest include:

- House air tightness levels, window specifications and orientation (e.g. design factors that will influence heating and cooling loads, and impact equipment and duct sizing);
- Front door orientation (e.g. information that will impact cooling loads and equipment sizing).
- Joist plan details (e.g. information needed to minimizes ductwork elbows and equivalent lengths);
- Heating equipment location (e.g. information needed to be able to specify supply trunk and bulk head locations);

2.2 Complete room-by-room heat loss and gain calculations

A room by room heat loss and heat gain calculation should be completed by the mechanical designer according to CSA F280-12, "*Determining the Required Capacity of Residential Space Heating and Cooling Appliances*". If the house orientation is known (preferred), the direction should be set before the F280 heating and cooling loads are calculated.

Guide when the house orientation is not known

If the HVAC system design is to be used in a number of different units of a particular model of tract-built homes where the front door orientation is not known, and varies from lot to lot, the designer should:

- Rotate the house orientation in 45-degree increments to determine the direction with the highest heating and cooling loads;
- Use the maximum heating and cooling loads to size equipment and design the ducting system[1].

The mechanical designer may wish to recommend envelope upgrades to the builder to reduce the equipment capacity required for space heating and space cooling.

1 Note that this approach ensures the heat loss and heat gain values reflect the "highest possible load" and may result in ductwork that is larger than needed for cases with lower actual loads. For this reason, designers are encouraged to use actual orientation as often as possible.

2.3 Divide the house floor plan into HVAC zones

Using the builder's input from the **Zoning Checklist** from the Builder Guide, the mechanical designer should divide the house into individual heating and cooling zones. Commonly used zoning plans are:

A. Assign one zone per floor including basement;

B. Group some floors into a single zone; and,

C. Custom zoning designs, with multiple zones on some floors.

Most tract-built houses can be suitably divided into two to four "roughly equal sized" HVAC zones to satisfy both comfort and energy considerations.

2.4 Determine zone heat loss and gain values

The mechanical designer can now group the room-by-room heat loss and gain results, calculated in Step 2.2, into zone-by-zone heat loss and gain values according to zoning decisions made in Step 2.3.

Testing for Equal Sized Zones

After the zone heat loss and gain values have been calculated, the appropriateness of the resulting zoning plan can be evaluated using the "equal sized" criteria shown in Table 2-1 for houses with 2, 3 or 4 HVAC zones.

Table 2-1: Target Range for Zone Heating Loads in Ducting Designs with "Equal Sized" Zones

No. of HVAC Zones (N)	Target Range for "Equal Sized" Individual Zone Heating Loads*
2	40% to 60% of total heating load
3	23% to 43% of total heating load
4	15% to 35% of total heating load

***Note:** Individual zones will sometimes fall slightly outside these guideline values, which is acceptable as long as the zone trunk sizes pass the "excessive air velocity / noise level" criteria discussed in Step 5.

The proposed zoning plan will satisfy the "equal-size" criteria if the heating load of each zone falls within the target range shown in Table 2-1. For example, a three-zone design should have zone heating loads that fall in the range of 23% to 43% of the total house heating load.

- Small exceptions above or below these recommended values are acceptable for individual zones.

- Zones with heating loads significantly below the guideline values may create operational challenges for the heating and cooling equipment during single-zone calls. The designer should consider adjusting the zone boundaries in order to re-balance the zone sizes.[2]
- In all cases the supply trunk sizes for all zones should pass the “excessive air velocity / noise level” criteria, which is discussed in detail in Step 5.

Upon completing Step 2, you will have:

☐ Confirmed or adjusted the builder’s initially defined zoning approach.

☐ Calculated the design heating and cooling loads for the overall house and the individual zones to be used in the equipment selection and sizing in STEP 3.

2 Note that modulating heating and cooling equipment and controls may allow for modulation of airflows and output that will enable designers to design zones that are above or below the target range provided in Table 2-1. In these cases, designers should follow manufacturer’s recommendations. Refer to Section 3.3 for further details.

STEP 3: DEFINE HEATING & COOLING EQUIPMENT REQUIREMENTS

Selecting the appropriate zoned equipment for a zoned HVAC installation can be undertaken in a five-part process including:

1. Choosing the air-distribution strategy and appropriate operating static pressure.
2. Choosing the type of zoned installation.
3. Choosing the approach to meet the reduced thermal demand of a single zone.
4. Choosing the changeover approach between heating and cooling.
5. Specifying the heating and cooling equipment output capacity.

3.1 Choose the air-distribution strategy

The mechanical designer should review the builder's preferred for heating equipment type and corresponding operating external static pressure (ESP) range (e.g. low, medium or high).

The builder and designer may also have a preference for a particular type of supply-air outlet location (i.e., perimeter floor or interior high wall) for the particular house model.

Using these preferences and the decision matrix shown in Table 3-1, the designer will be able to determine:

- If the requested air distribution system falls within the scope of the ***Zoning Duct Design Guide***,
- Recommendations for suitable types of supply grilles / diffusers to be used in the zoned duct design.

Table 3-1: Decision Matrix for Checking the Applicability of the ***Zoning Duct Design Guide***

Example HVAC Equipment Operating External Static Pressure (ESP)	**OPTION A: Traditional Supply Ducts** (emphasizes perimeter floor outlets)	**OPTION B: Central Supply Ducts** (emphasizes interior high wall outlets)
Zoning Checklist for Builders **Option A: LOW** (ESP generally ≤ 0.5-in w.g. or 125 Pa)	**Within scope when used with all types of supply grilles / diffusers** (See Step 5 for details)	**Within scope when designed & installed with appropriate supply grilles / diffusers** (See Step 5 for details)
Zoning Checklist for Builders **Option B and C: MEDIUM and HIGH** (ESP generally > 0.5-in w.g. or 125 Pa)	**Outside scope** Medium and high ESP supply duct designs are not currently covered by HRAI Residential Air Systems Design and as such fall outside the scope of this *Zoning Duct Design Guide*. **The methodology followed in this Guide can be used to inform medium and high ESP supply duct designs.**	**Outside scope** Medium and high ESP supply duct designs are not currently covered by HRAI Residential Air Systems Design and as such fall outside the scope of this *Zoning Duct Design Guide*. **The methodology followed in this Guide can be used to inform medium and high ESP supply duct designs.**

OPTION A: Traditional Supply Duct Layout

Current duct design practices can be used to design zoned duct systems using the traditional supply outlet plan. The main change to the traditional duct design in order to enable zoning is:

- Splitting and re-sizing the supply trunk into separate supply trunks, one for each zone as shown in Figure 3-1.

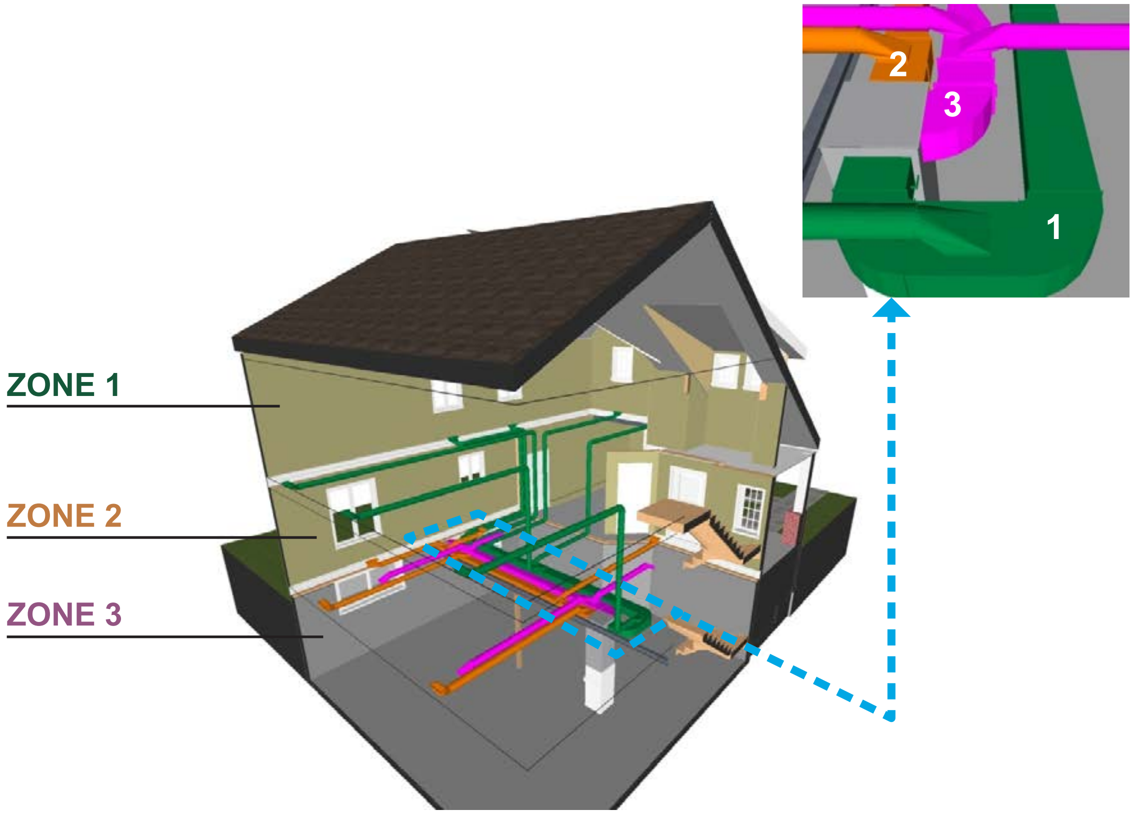


Figure 3-1: Floor-by-floor Zoned Ducting using OPTION A: Traditional Supply Ducts

The **Traditional Supply Duct Layout** uses standard locations for supply-air outlets and return-air inlets and common duct fabrication practices.

The advantages of the **OPTION A: Traditional Supply** designs are:

- It minimizes changes to duct design practices for designers;
- It is fabricated using the same materials as traditional non-zoned duct systems; and,
- It minimizes duct installation changes.

Additional planning for implementing **OPTION A: Traditional Supply Duct** designs may include:

- Changes in equipment suppliers for the builder and HVAC installer depending on the type of zoned equipment selected; and,
- Minor re-training of installers on the specific zoned equipment requirements (e.g. coordinating of zone thermostats wiring with supply zones).

A completed example of a zoned duct design that uses **traditional supply ducts** is provided in Appendix A.

OPTION B: Central Supply Duct Layout

This **Central Supply Duct Layout** deviates from standard design practice.
It may include:

- Supply distribution trunks and branches that are located more centrally within the structure of the house.
- Supply outlets that are located high on interior walls blowing air horizontally across the top of rooms, or using ceiling diffusers as shown in Figure 3-2.

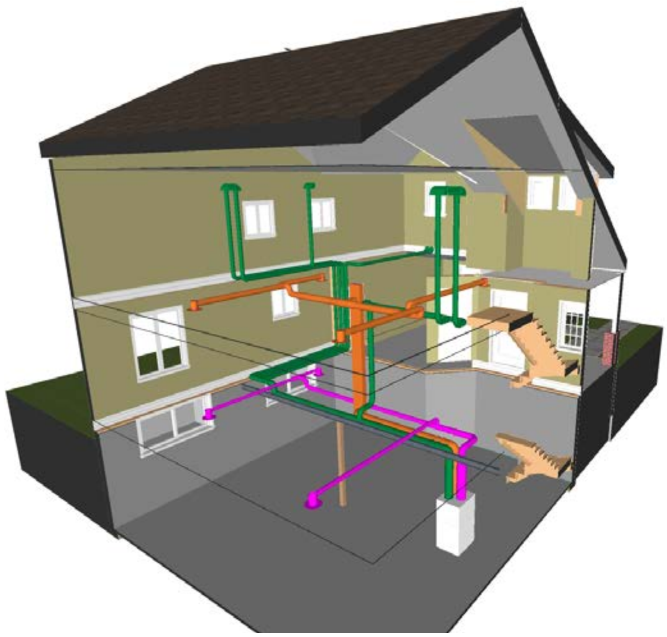


Figure 3-2: Floor-by-floor Zoned Ducting using OPTION B: Central Supply Ducts

The advantages of the **OPTION B: Central Supply** designs may include:

- Reduced duct lengths contributing to reduced ducting costs
- High wall supply outlets that provide superior cooling distribution on upper floors.
- Supply outlets on walls or ceilings which do not interfere with the placement of furniture.

Additional planning for implementing **OPTION B: Central Supply Duct** designs may include:

- Changes to duct design practices commonly used by mechanical designers;
- The use of different ducting materials and grille/diffuser types (that ensure adequate flow of air to outside walls (i.e., "throw");
- May require changes in equipment suppliers; and,
- Re-training of installers on the use of different ducting materials, duct installation techniques and on the specific zoned equipment requirements (e.g. coordinating of zone thermostat wiring with supply zones).

Details on how to implement the **OPTION B: Central Supply Duct** Layouts are provided in STEP 5 of this ***Zoning Duct Design Guide***.

A completed example of a zoned duct design that uses **central supply ducts** is provided in Appendix B.

3.2 Choose the type of zoned installation

Using the **Air Distribution Strategy** selected in Section 3.1, and the builder's input from the **Zoning Checklist for Builders**, the mechanical designer should choose the type of HVAC equipment to be connected to the zoned ducting system. The choices may include:

A. Factory-integrated Zoned HVAC Equipment;

B. Site-assembled Zoned HVAC equipment; and,

C. Zone-Ready Duct Installation with non-zoned HVAC Equipment.

OPTION A: Factory-integrated Zoned HVAC Equipment

Factory-integrated zoning solutions are shipped with all zoning controls and air-flow dampers pre-assembled in a single box. Factory-integrated zoned systems have:

- Straightforward equipment installations, requiring duct connections to a zoned duct system and control wiring to one thermostat per zone.
- Installation and commissioning requirements slightly more onerous than equivalent single-zone equipment.
- Enhanced comfort and energy-saving features compared to single-zone HVAC systems.

OPTION B: Site-assembled Zoned HVAC Equipment

Site-assembled zoning solutions require building-up a zoned system from multiple components sourced from one or more suppliers. Site-assembled zoned systems have:

- Automatic zoning dampers installed in each of the zone supply trunk ducts near the plenum,
- An external zoning controller, one thermostat per zone and heating and cooling equipment connected together using field-installed control wiring.
- Installation and commissioning requiring more time and expertise than single-zone equipment.
- Enhanced comfort and energy-saving features compared to single-zoned HVAC systems, for most site-assembled zoned HVAC systems.

Exceptions are:

- Zoned systems using by-pass dampers as their primary means of capacity control (see Section 3.3 for details); These types of zoned systems may have lower efficiency and increased energy usage, and are not ideal for installation in residential new construction.

OPTION C: Zone-Ready Duct Installation

As a design option, the builder may decide to install zoned ducting with traditional non-zoned HVAC equipment controlled by a single main-floor thermostat.

- This type of installation is referred to as a “Zone-Ready” duct installation.
- The Zone-Ready duct system will improve system airflow effectiveness, helping to get conditioned air to where it is intended to go.
- The Zone-Ready duct system will enable factory-integrated zoned HVAC, with automatic zone dampers, to be installed at a later date without incurring expense to retrofit the ductwork.

If a Zone-Ready duct installation is selected, the designer may skip ahead to Section 3.4.

3.3 Choose approach to meeting demand from a single zone

Operation of centrally zoned HVAC systems differ from non-zoned HVAC systems in that during most heating and cooling calls only one zone supply trunk will be open[3], which will tend to restrict the airflow from the equipment. As a result, the heating and cooling equipment in zoned HVAC systems needs to:

- Automatically adapt operation to reduce heating or cooling output and airflow, and/or
- Deliver higher than normal design air flow to the single zone in order to limit temperature-rise values during heating, and avoid evaporator freeze-up during cooling.

The mechanical designer should confirm the builder’s choice of control and select zoned equipment manufacturers and models appropriately. Control options to handle single-zone calls include:

A. System modulates or stages airflow and possibly thermal output to maintain acceptable operating conditions (preferred approach);

B. System directs some airflow to non-calling zones to maintain minimum airflow requirements, and possibly modulates or stages airflow and thermal output; or,

C. System uses a by-pass damper to recirculate conditioned supply air to the equipment return.

Control options A and B are normally implemented by the equipment manufacturer at the time of the zoned equipment design. The mechanical designer will need to refer to the manufacturer’s literature or contact the manufacturer directly to determine which method of control is used by specific equipment. From an equipment efficiency perspective, Option A is the preferred approach. Option B with modulating or staged equipment works well, while Option C should be avoided unless required.

3 Some zone damper designs allow a small amount of air to pass by even when the damper blades are in the fully closed position. This design feature helps ensure adequate airflow through the equipment, while still directing the majority of the airflow to the zone(s) calling for heating or cooling.

- **Factory-integrated zoned equipment** will normally have built-in control strategies, typically based on control option A or B, for dealing with the range of outputs expected. Once the designer has confirmed that the zoned ducting plan falls within the equipment manufacturer's guidelines, there is no further action required.
- **Site-assembled zoned systems with all major components from a single manufacturer** are normally designed to work together, and will have built-in control strategies, typically based on control option A or B, for dealing with the range of outputs expected from zoned duct designs. Once the designer has confirmed that the equipment selections and zoned ducting plan falls within manufacturer's guidelines, there is no further action required.
- **Site-assembled zoned systems built-up from components from different suppliers** may be unable to communicate with each other or coordinate their operation to modulate the heating or cooling output and airflows to satisfy the range of thermal outputs required.
  - These zoned systems commonly operate at full capacity and use bypass dampers (Option C) to re-direct excess supply airflow to the return duct as the primary method of relieving excess pressure. This may lower equipment operating efficiency and increase energy usage.
  - The mechanical designer should confirm that the zoned system can operate as intended. The designer may need to develop the control strategy in detail and check that the resulting zoned system will maintain both heating and cooling equipment operating parameters within design limits over all possible operating scenarios.

3.4 Choose changeover approach between heating and cooling

The mechanical designer should confirm the builder's choice of changeover approach and select zoned equipment manufacturers and models appropriately. Changeover options to handle switching between heating and cooling modes include:

A. Zone controller enables the occupant to seasonally switch-over the system from heating to cooling using a central, manual switch.

B. Zone controller automatically switches between heating and cooling based on individual zone thermostat settings.

The default changeover option A or B is determined by the equipment manufacturer at the factory. The mechanical designer should refer to the manufacturer's literature or contact the manufacturer directly to determine which control changeover approach is used by specific equipment. In some cases the changeover approach option can be adjusted in the field by the HVAC technician.

- **Factory-integrated zoned equipment** will commonly use zone controllers that are "hard-wired"[4] to use the ***Option A*** changeover approach.

4 "Hard-wired" control options apply to both relay-logic and electronic controls which are set at the factory and are not adjustable by the HVAC technician.

- **Site-assembled zoned systems with all major components from a single manufacturer** will commonly use zone controllers that have the default changeover approach set to ***Option B***. Depending on the manufacturer and model of controller, the changeover approach may or may not be adjustable by the HVAC technician.

3.5 Specify the equipment output capacity

Following from the heating and cooling load calculations completed in STEP 2, the mechanical designer should calculate the heating and cooling equipment sizes according to CSA F280-12, "*Determining the Required Capacity of Residential Space Heating and Cooling Appliances*".

An example of an equipment design summary is shown in Table 3-2 for a two-storey detached home with basement which has been zoned by floor into three zones. In this example the thermal loads seen by the equipment at design conditions are 42,000 Btuh (12.3 kW) for heating and 28,600 Btuh (8.38 kW) for cooling.

Heating System: The mechanical designer should select an appropriate size of heating equipment to satisfy the total design heating load for the house, which will also define maximum airflow requirements during heating.

A guideline for **zoned heating appliances** is to size equipment output as close as possible to 100% of the calculated total equipment heating load.

- This sizing guideline will minimize oversizing and keep heating airflow as low as possible, which will help minimize supply duct sizes.
- Zoned heating systems are seldom required to operate with all zones calling simultaneously, so recovery times from setback / setforward strategies will be above average.

In the example in Table 3-2, the heating appliance selected has an output of 47,700 Btuh (14.0 kW) (i.e., 114% of total heating load) at an airflow of 800 cfm (378 L/s).

Table 3-2: Example Equipment Design Summary for a 3-zone Duct Design

Parameter	Heating Loads (imperial units)	Cooling Loads (imperial units)	Heating Loads (metric units)	Cooling Loads (metric units)
Weather location	Ottawa, ON Canada	Ottawa, ON Canada	Ottawa, ON Canada	Ottawa, ON Canada
Envelope Loads (from Step 2) Second-floor zone	14,235 Btuh	10,271 Btuh	4,172 W	3,010 W
Envelope Loads (from Step 2) Main-floor zone	12,511 Btuh	9,967 Btuh	3,666 W	2,921 W
Envelope Loads (from Step 2) Basement zone	8,345 Btuh	853 Btuh	2,446 W	250 W

Parameter	Heating Loads (imperial units)	Cooling Loads (imperial units)	Heating Loads (metric units)	Cooling Loads (metric units)
Subtotal of envelope loads	**35,091 Btuh**	**21,091 Btuh**	**10,284 W**	**6,181 W**
Other sensible loads Ventilation sensible loads (vent @ 75 cfm or 35 L/s)	6,885 Btuh	891 Btuh	2,018 W	261 W
Equipment sensible loads	**41,976 Btuh**	**21,982 Btuh**	**12,302 W**	**6,442 W**
Latent loads Internal latent loads	n/a	1,474 Btuh	n/a	432 W
Latent loads Ventilation latent loads (vent @ 75 cfm or 35 L/s)	n/a	5,120 Btuh	n/a	1,501 W
Equipment latent loads	**n/a**	**6,595 Btuh**	**n/a**	**1,933 W**
Equipment total loads	**41,976 Btuh**	**28,577 Btuh**	**12,302 W**	**8,375 W**

EQUIPMENT SPECIFICA-TIONS	Heating Equipment	Cooling Equipment	Heating Equipment	Cooling Equipment
Efficiency	94.0 AFUE	12.0 EER, 14 SEER	94.0 AFUE	12.0 EER, 14 SEER
Input rating	50,700 Btuh	1.73 kW	14.9 kW	1.73 kW
Output rating	47,700 Btuh	24,200 Btuh	14.0 kW	7.09 kW
Actual air flow at rated output	800 cfm	800 cfm	378 L/s	378 L/s

Cooling System: The mechanical designer should select an appropriate size of cooling equipment, which will also define the maximum airflow requirements during cooling.

A guideline for **zoned cooling appliances** is to size equipment output between 80% and 100% of the calculated total equipment cooling load[5], and to avoid oversizing the cooling equipment if possible.

- This sizing guideline will keep cooling airflow as low as possible, which will help minimize supply trunk sizes.

5 The sizing guideline for zoned air-conditioner capacity is a modification of the HRAI sizing guideline for non-zoned systems, which recommends air-conditioner condenser capacity of 80% to 125% of total cooling load. Note that some multi-stage or variable capacity air-conditioner systems may have lower stage/lower capacity outputs that are well matched to the cooling load. Such systems, even if "over-sized" when operating at maximum capacity, may be preferable to a smaller capacity, single stage / non-variable capacity system.

- Since zoned cooling systems are seldom required to operate with all zones calling, the smaller air-conditioner capacity will be sufficient, and will improve dehumidification performance.
- Note that properly sealed ductwork helps ensure that conditioned air is being delivered as designed (and getting to where it was intended to go). This is of key importance when considering cooling equipment sized below 100% of cooling load. Refer to Section 5.6 for further details.

In the example in Table 3-2, the cooling appliance selected has an output of 24,200 Btuh (7.09 kW) (i.e., 85% of total cooling load) at an airflow of 800 cfm (378 L/s).

A complete worked example for this zoned ducting system is available in Appendix A.

Upon completing Step 3, you will have:

- ☐ Chosen the air distribution strategy to be implemented in STEP 5;
- ☐ Confirmed or adjusted the builder’s selection of external static pressure (ESP) for the HVAC system;
- ☐ Confirmed or adjusted the builder’s selection of zoned equipment type to be installed;
- ☐ Narrowed the possible suppliers of the zoned equipment based on zoning control features; and,
- ☐ Calculated the required thermal output values for the zoned heating and cooling equipment.

STEP 4: SPECIFY THE RETURN-AIR DUCTING REQUIREMENTS

4.1 Specify return-air duct installation method

The mechanical designer should specify the return duct installation method as either:

C. Joist-to-trunk Return Installation; or

D. Hard-ducted Return Installation.

OPTION A: Joist-to-trunk Return Installation

This is a "*no change from current practice*" option which typically uses:

- Joist and stud cavities, supplemented with joist linings, joist block ends and some hard pipe as return branches, terminating in a rectangular return trunk in the basement, which is connected to the equipment.

OPTION B: Hard-ducted Return Installation

In this installation option, the return duct is tightened up, which will minimize leakage and improve air distribution effectiveness. This is achieved by:

- Hard ducting the complete return system using rigid round, oval or rectangular ducting;
- Avoiding the use of unlined joist and stud cavities as return ducts.

4.2 Specify location of return-air inlets

The mechanical designer should detail the design of the return-air inlets as the following:

A. Standard Return Inlet Layout; or

B. Simplified Return Inlet Layout.

OPTION A: Standard Return Inlet Layout

This is a "*no change from current practice*" option which typically uses:

- Multiple return-air inlets on each floor.
- Return locations determined by a code-compliant duct design procedure such as *HRAI's Residential Air System Design (RASD) Manual for Air Heating/Cooling Systems* or equivalent.

An example of the standard return inlet layout in a two-storey house, installed using the joist-to trunk return installation method is shown in Figure 4-1.

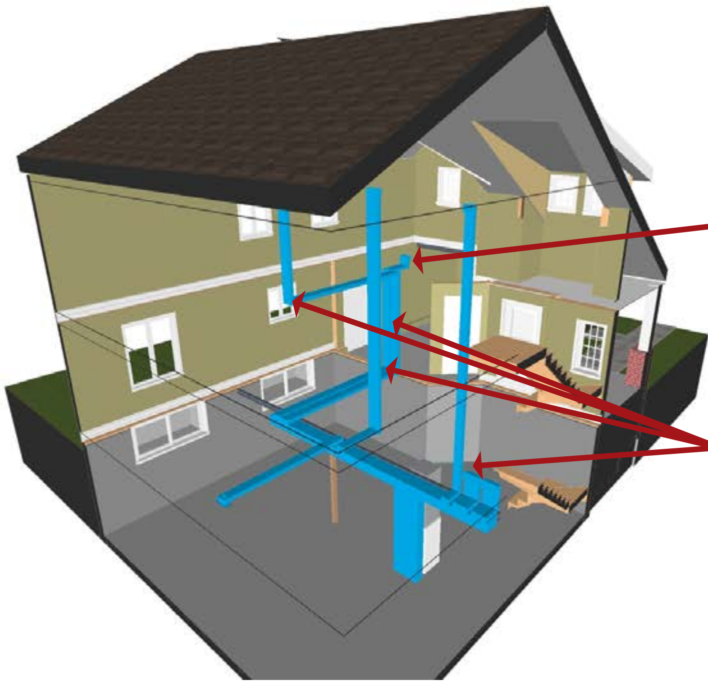


Figure 4-1: Example of a Standard Return Duct System in a Two-Storey House

OPTION B: Simplified Return Duct Layout

This return ducting option is for builders and designers who have chosen to implement a **Simplified Return**. This return plan:

- Is most effective in multi-storey home designs.
- Uses a simplified design which may reduce installation costs and enhance air-distribution system effectiveness.
- Should use the “hard-ducted” return installation method.

A procedure that may be followed for locating return-air inlets using the **Simplified Return Inlet Layout** is as follows:

- Locate one return-air inlet centrally in the basement at floor level and connect it to an independent return trunk in close proximity to the equipment.
- Locate another return-air inlet at the highest point in the home which is central and open to other levels/floors (e.g. upper floor central hallway).
- In any rooms with an un-heated space below (e.g., rooms over garages, porches, etc.), the designer should locate a low-wall, baseboard or preferably a floor return in the room. It should be placed as far as practical from the supply outlet located in the room and be hard piped /ducted back to the return trunk.
- Local code authorities will likely require at least one return inlet per floor. However, if there is no airflow separation between the main and upper floors the designer might consider consulting with the local authority and omitting a return for the main floor.
- If an HRV is connected to the return air trunk, the designer should treat is as a return air inlet.

- If only two or three return inlets are provided, the grilles and hard pipe/duct branches should be sized to return the full volume of equipment design airflow (i.e. cubic feet per minute or cfm).

The best-practice applications of the various return placements are described as follows:

High-wall Return Inlets

Applications:

- This return placement is particularly beneficial and should be used on the highest level of the home with heated space below (which is main floor of the home if a bungalow with heated basement).
- Floors with higher design cooling loads than heating loads will benefit from high-wall returns

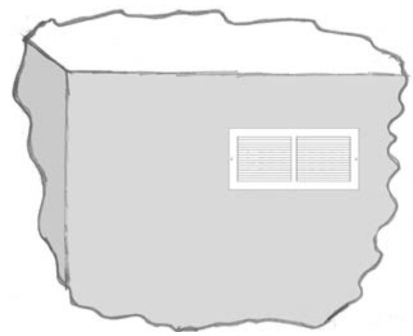


Figure 4-2: High Wall Return Inlet

Low-wall, Baseboard and Floor Return Inlets

Applications:

- These return placements should be used on main floors and in basements (i.e., floors that have higher design heating loads than cooling loads).
- Floor return inlets should also be used on upper floors in rooms with unheated space below. Baseboard or low-wall returns may be used as an alternative if a floor return is not feasible.

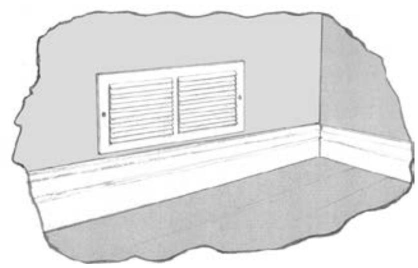


Figure 4-3: Low Wall Return Inlet

An example of the simplified return inlet layout in a two-storey house, installed using the hard-piped return installation method is shown in Figure 4-4.

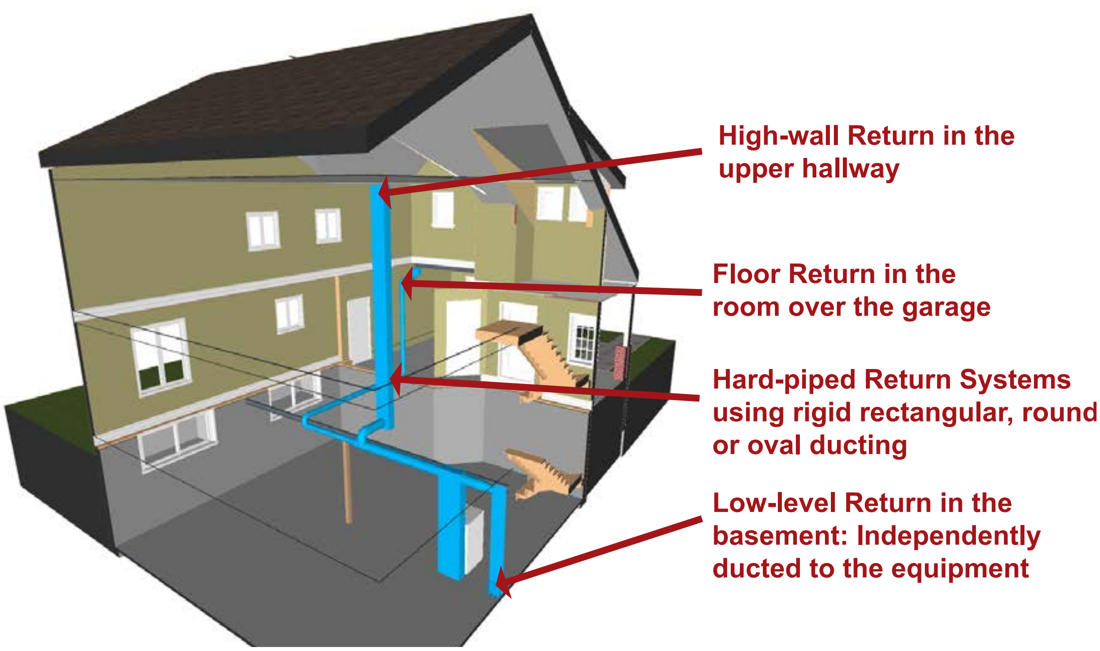


Figure 4-4: Example of a Simplified Return Duct System in a Two-Storey House

4.3 Layout return-air ducts

The designer should layout the duct routes from each of the return inlets back to the furnace/air handler.

Best Practice Ducting for Basement Returns

Using best practice, the basement return should be routed to the furnace or air handler independently of any main and upper zone returns.

4.4 Specify return-air duct sizing

The designer should follow a step-by-step code-compliant duct sizing procedure such as that outlined in *HRAI's Residential Air System Design (RASD) Manual for Air Heating/Cooling Systems*, or equivalent.

Upon completing STEP 4, you will have:

- ☐ Specified the type of return branch and return trunk ducting and installation method,
- ☐ Specified the location, size and placement of return-air inlets in the home,
- ☐ Defined the return duct routing on the house plans,
- ☐ Specified the size of the return branches and the return trunk ducting.

STEP 5: SPECIFY THE SUPPLY-AIR DUCTING REQUIREMENTS

5.1 Specify location of supply-air outlets

Following from the *Air Distribution Strategy* decision made in STEP 3.1, the designer may now layout the supply-air ducting following:

C. Traditional supply ducts using primarily perimeter floor outlets; or,

D. Central supply ducts using interior high wall outlets and other outlet placements, depending on the specific requirements of the individual rooms or structural limitations.

Note that all rooms need supply outlets with the following exceptions:

- Rooms which do not have outside wall exposure, and are not “habitable” rooms
- Rarely used rooms or spaces such as closets which do not have windows

OPTION A – Traditional Supply Duct Layout

This is a “*minimal change from current practice*” option which will typically use:

- Perimeter floor outlets, or
- Ceiling outlets.

OPTION B – Central Supply Duct Layout

This supply option is for builders and designers who have chosen to implement **Central Supply Ducts** which make use of primarily *interior high-wall and potentially ceiling registers*.

In this approach the designer may:

- Make decisions on which type of supply outlet to be used in each room such as
  - Interior high wall outlets,
  - Ceiling outlets,
  - Perimeter low wall outlets, or
  - Perimeter floor outlets.
- Layout supply outlets on the plan and identify the grille types required at each location.

The best-practice applications for the various outlet placements, with recommended grille/diffuser types, are described in the following paragraphs.

Perimeter Floor Outlets

Applications:

- This outlet placement is particularly beneficial and should be used in rooms on the main and upper floors with unheated spaces below **(both Options A and B)**.
- Designers implementing **Option A: Traditional Supply Ducts** may choose this outlet placement for all rooms within the finished space of the home.

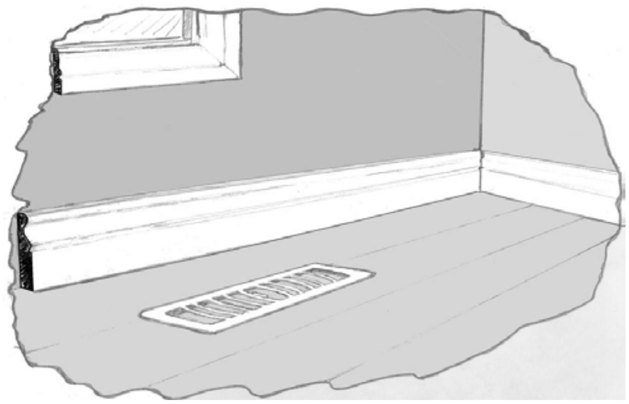


Figure 5-1: Perimeter Supply Outlet with Floor Diffuser

Interior High Wall Outlets

Applications:

- In **Option B: Central Supply Ducts** this outlet placement may be particularly useful for providing summer comfort on upper floors. It can get conditioned air to the top of the home where warm air is most likely to pool.
- This outlet placement can also be used on the other floors with heated space below when implementing **Option B: Central Supply Ducts**.
- Interior high-wall supply outlets require the use of long-throw diffusers to allow conditioned air to penetrate across the width of the room. Round diffusers (not shown) may be used.

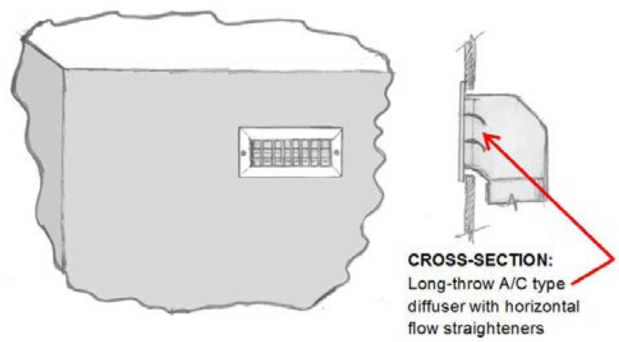


Figure 5-2: Interior High Wall Supply Outlet, shown with a Rectangular Diffuser

Ceiling Outlets

Applications:

- This outlet placement can be used on intermediate floors, with heated space below, as an alternative to interior high wall outlets when implementing **Option B: Central Supply Ducts**.
- This outlet placement is also commonly used in unfinished basements **(both Options A and B**).

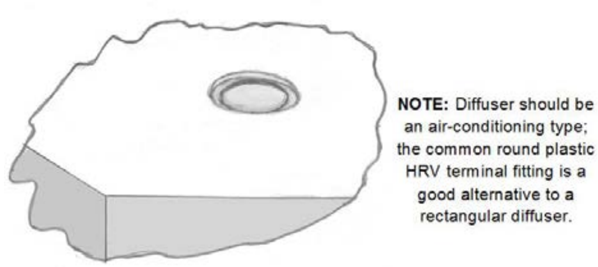


Figure 5-3: Ceiling Supply Outlet, shown with a Round Diffuser

Perimeter Low Wall Outlets

Applications

- This approach can be useful in finished basements where there is no in-floor heating system (both Options A and B).
- The supply outlets should be located low-wall at the perimeter in all rooms where comfort is expected.

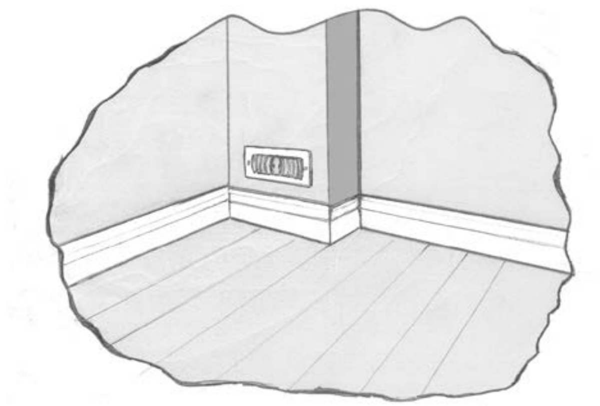


Figure 5-4: Perimeter Low Wall Supply Outlet

5.2 Specify type of ducts used for supply branches

The mechanical designer should specify using rigid, round ducting for supply branches. Flexible ductwork may be used provided the designer has taken into consideration appropriate equivalent length calculations when sizing the ductwork.

5.3 Layout supply-air ducts

Based upon standard practices and the notes provided in this section, the designer can now:

- Layout the duct routes from each of the supply outlets back to the air-handler/furnace on the house plans.

There should be one supply trunk (ST) for each zone. For example, in a three-zone system zoned by floor:

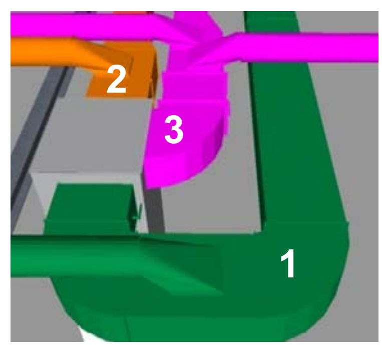


Figure 5-5: Each Zone has a separate supply trunk (ST)

- The second floor zone branches should be collected into trunk “ST1”,
- The main floor zone branches should be collected into trunk “ST2”,
- The basement zone branches should be collected into trunk “ST3”,
- All of the trunks should end up back at the plenum of the furnace or air handler as illustrated in Figure 5-5.

Coordinate routing with framing:

By coordinating the duct design with the joist and framing plan, the mechanical designer should specify a supply-air duct layout with as few 90-degree elbows as possible.

An example of coordinating the duct layout with the joist and framing plan is shown in Figure 5-6.

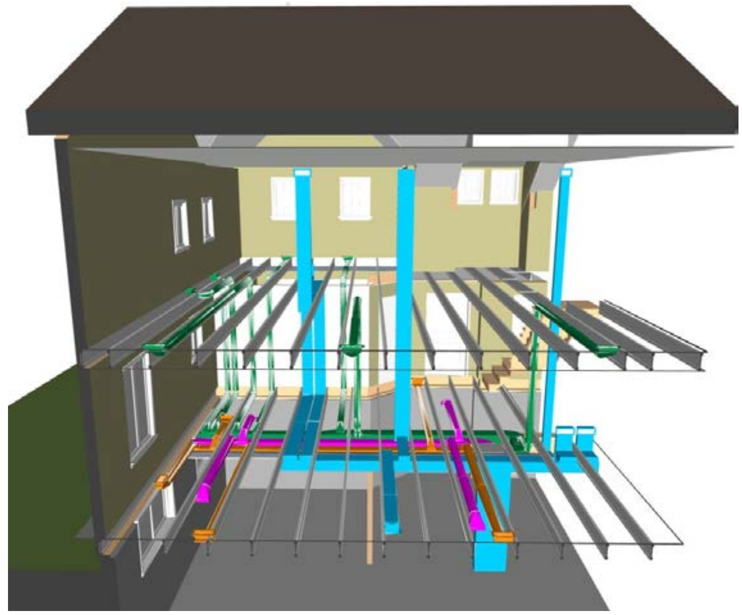


Figure 5-6: Example of coordinating the layout of ducts with the framing plan to minimize use of elbows

5.4 Specify type of ducts used for the zone supply trunks

OPTION A – Traditional Rectangular Ductwork

Supply trunks have traditionally been fabricated as rectangular ducting which is hung below the floor joists in the basement.

This technique can be used with zone supply trunks as shown in Figure 5-7, and will result in minimal ducting changes when transitioning to a zoned HVAC system.

Figure 5-7: Three Rectangular Zone Supply Trunks, with the Return Trunk shown on the Left

OPTION B – Round or Oval Ductwork

As a design option, the mechanical designer should specify the use of round or oval ducts instead of square ducting wherever possible. An example of using round supply trunks is shown in Figure 5-8.

Figure 5-8: Three Round Zone Supply Trunks, with the Return Trunk shown on the Left

- Round ducting and fittings are readily available and will eliminate the need for most custom fabrication.
- Round ducts are easier to seal, and will eliminate “hidden” supply take-offs (common with square ducts), which are difficult to seal and prone to high air leakage.
- Round ducts may allow for higher airflow velocities than rectangular ducts to achieve equivalent acoustic design criteria.[6]

6 Refer to the ASHRAE Handbook – HVAC Applications in the References section for further details.

5.5 Specify supply-air duct sizing

With zones applied to the floor plans and the supply-air duct layout sketched onto floor plans, the mechanical designer should follow a step-by-step code-compliant duct sizing procedure as outlined in HRAI's "*Residential Air System Design (RASD) Manual*".

In many situations, the mechanical designer can optimize the trial layout design zone by zone, usually starting with the farthest outlet for each zone trunk and working backwards to the beginning of the trunk. An example of a three dimensional model of a zoned duct system is provided sequentially by zone in Figures 5-9, 5-10 and 5-11.

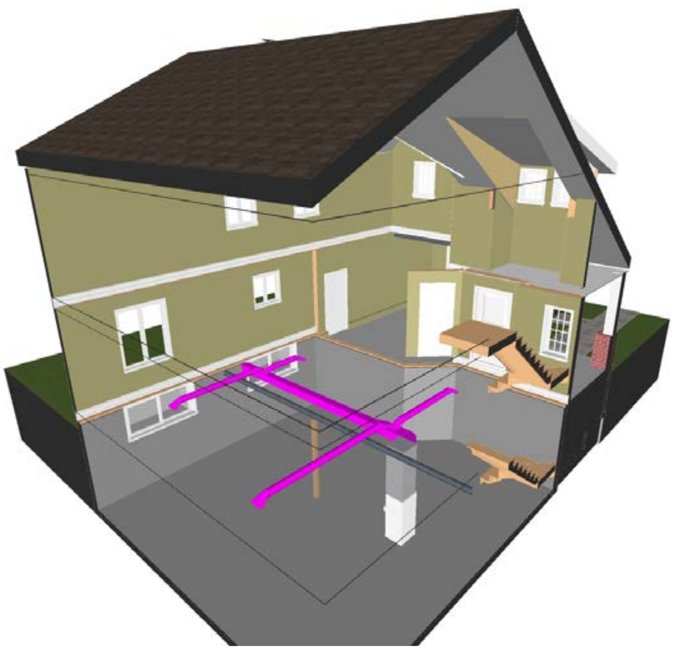


Figure 5-9: Supply Ducts for Basement Zone

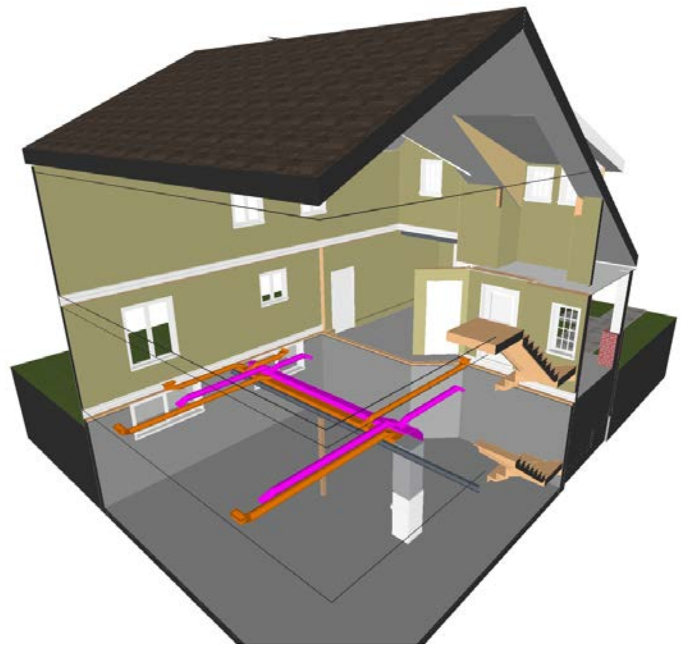


Figure 5-10: Supply Ducts for Basement & Main Floor Zones

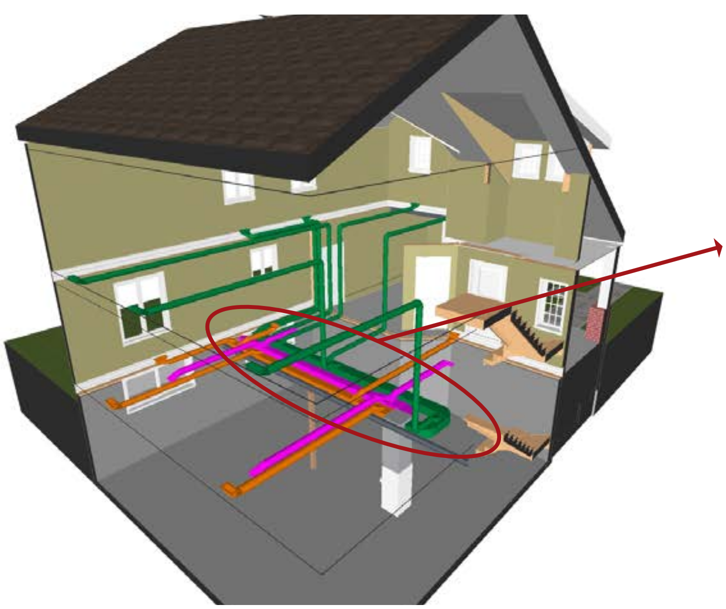


Figure 5-11: Supply Ducts for Basement, Main Floor and Second Floor Zones

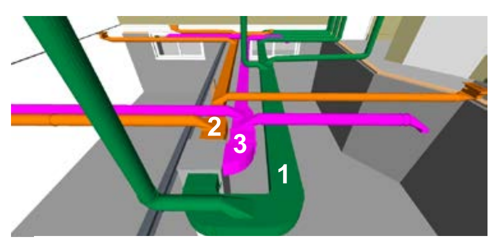


Figure 5-11 INSERT: Each Zone has a separate supply trunk connected to the equipment plenum (e.g. "1", "2", & "3" for second-floor, main-floor & basement zones).

Zone Supply Trunk Sizing

Sizing the zone supply trunks is a two-part process involving:

1. Preliminary zone trunk sizing based on the design airflow requirements.
2. Checking the zone trunks for excessive air velocity / noise during single-zone operation.

Preliminary zone supply trunk sizing based on design airflow requirements

Table 5-1 (imperial units) and Table 5-2 (metric units) summarize the preliminary design details of supply trunks for an example three-zone system. Additional details on this zoned HVAC system design are provided in Appendix A.

Table 5-1: Example of a preliminary supply trunk (ST) design for a 3-zone system (imperial)

Supply Trunk Name	Heating airflow (cfm)	Cooling airflow (cfm)	Design airflow (cfm)	Design velocity (fpm)	Trunk height (in.)	Trunk width (in.)	Trunk area (sq-in)
Second Floor | **ST1**	**325**	**390**	**390**	**878**	**8.0**	**8.0**	**64.0**
Second Floor | ST1A	104	139	139	417	6.0	8.0	48.0
Main Floor | **ST2**	**285**	**378**	**378**	**851**	**8.0**	**8.0**	**64.0**
Main Floor | ST2A	169	201	201	604	6.0	8.0	48.0
Basement | **ST3**	**190**	**32**	**190**	**570**	**6.0**	**8.0**	**48.0**
Basement | ST3A	114	19	114	513	4.0	8.0	32.0
Total	**800**	**800**	**800**	**–**	**–**	**–**	**–**

Table 5-2: Example of a preliminary supply trunk (ST) design for a 3-zone system (metric)

Supply Trunk Name	Heating airflow (L/s)	Cooling airflow (L/s)	Design airflow (L/s)	Design velocity (m/s)	Trunk height (mm)	Trunk width (mm)	Trunk area (mm^2)
Second Floor | **ST1**	**153**	**184**	**184**	**4.46**	**203**	**203**	**41,290**
Second Floor | ST1A	49	66	66	2.12	152	203	30,968
Main Floor | **ST2**	**134**	**178**	**178**	**4.32**	**203**	**203**	**41,290**
Main Floor | ST2A	80	95	95	3.07	152	203	30,968
Basement | **ST3**	**90**	**15**	**90**	**2.90**	**152**	**203**	**30,968**
Basement | ST3A	54	9	54	2.61	102	203	20,645
Total	**378**	**378**	**378**	**–**	**–**	**–**	**–**

Each rectangular supply trunk has two sections.

- Supply trunk 1 (ST1), servicing the second-floor zone, starts at the plenum as an 8 in. by 8 in. (203 mm by 203 mm) duct and tapers into a smaller downstream section ST1A sized at 6 in. by 8 in. (152-mm by 203-mm).
- Supply trunk 2 (ST2), servicing the main-floor zone, starts at the plenum as an 8 in. by 8 in. (203 mm by 203 mm) duct and tapers into a smaller downstream section ST2A sized at 6 in. by 8 in. (152-mm by 203-mm).

- Supply trunk 3 (ST3), servicing the basement zone, starts at the plenum as a 6 in. by 8 in. (152 mm by 203 mm) duct and tapers into a smaller downstream section ST3A sized at 4 in. by 8 in. (102-mm by 203-mm).

The air velocities in all sections of the zone trunks are calculated to be below the maximum limit of 900 fpm (4.57 m/s) at design conditions as required by HRAI for low-velocity systems.

Checking for excessive air velocity/noise levels during single-zone operation

When a single zone is calling for heating or cooling, the operation of centrally zoned HVAC equipment may require that individual supply trunks carry higher air volumes than the values calculated from standard design practices. The higher air volume during a single-zone call can lead to excessive air velocity and noise levels if the zoned HVAC equipment does not modulate airflow or if the supply trunks are too small.

Note: Systems that modulate airflow and output may incorporate features such as an airflow verification check or field adjustable zone airflow settings that can help alleviate excessive air velocity / noise levels during single-zone operation. Refer to Section 3.2 and 3.3 for guidance in selecting this type of equipment. Also, selecting round or oval supply ductwork and ensuring high levels of air sealing can allow for higher duct velocities without resulting noise concerns. Refer to Sections 5.4 and 5.6 for related guidance.

Noise Test Conditions: The mechanical designer should calculate and check the air velocity in each of the zone supply trunks at a “noise test” condition which simulates single-zone operation, as follows:

- Any zone trunk moving 50% or more of the total system design airflow should be “noise tested” at the design airflow for that trunk.
- Any zone trunk moving less than 50% of the total system design airflow should be “noise tested” as if that supply trunk is moving 50% of the total system design airflow at the plenum connection, before any transition, taper or supply branch takeoff.
- If the zone supply trunk includes transitions or tapers to smaller downstream sections, the “noise test” airflow for the downstream sections should be adjusted by the “% trunk airflow fraction” calculated at design airflow conditions for that trunk.

Noise Test Velocity Limits: If the air velocity in the zone trunk at the plenum connection, or immediately after any transition or taper, is greater than 900 fpm (4.57 m/s)[7] for low-velocity systems, the designer should either:

- Increase the trunk-section size until the velocity is less than or equal to 900 fpm (4.57 m/s), or
- Determine if the design airflow can be reduced to a level that will reduce the “noise test” velocity to less than or equal to 900 fpm (4.57 m/s), while still meeting the building heating and cooling requirements and operating the HVAC equipment within normal limits.See above Note for details.

7 Designers of zoned systems using medium or high-velocity technology may apply the “Noise-Test” method without a specific velocity limit to identify if any of the zone trunks are undersized by looking for velocity outliers among the “Noise-Test” results, and when necessary increase the trunk sizes to bring the velocities in line with the other supply trunk values.

Example of checking for excessive velocity/noise during single-zone operation

Table 5-3 (imperial units) and Table 5-4 (metric units) provide examples of applying the "noise test" to the preliminary supply trunk sizes for the previously described three-zone system which was designed with rectangular supply trunks.

The following paragraphs describe the "noise test" calculations and summarize the results for the example system.

Table 5-3: Example of checking zone supply trunk (ST) sizes for "noise test" levels (imperial)

Supply Trunk Name	Heating airflow (cfm)	Cooling airflow (cfm)	Design airflow (cfm)	Design velocity (fpm)	Trunk height (in.)	Trunk width (in.)	Trunk area (sq-in)	Trunk Sec. airflow ratio	Noise Test Airflow (cfm)	Noise Test Velocity (fpm)
Second Floor | **ST1**	**325**	**390**	**390**	878	8.0	8.0	64.0	**100.0%**	**400**	900
Second Floor | ST1A	104	139	139	417	6.0	8.0	48.0	35.6%	142	PASS 427
Main Floor | **ST2**	**285**	**378**	**378**	851	8.0	8.0	64.0	**100.0%**	**400**	900
Main Floor | ST2A	169	201	201	604	6.0	8.0	48.0	53.2%	213	639
Basement | **ST3**	**190**	**32**	**190**	570	6.0	8.0	48.0	**100.0%**	**400**	1200
Basement | ST3A	114	19	114	513	4.0	8.0	32.0	60.0%	240	FAIL 1080
Total	**800**	**800**	**800**							
50% of total system design flow = 400										

Table 5-4: Example of checking zone supply trunk (ST) sizes for "noise test" levels (metric)

Supply Trunk Name	Heating airflow (L/s)	Cooling airflow (L/s)	Design airflow (L/s)	Design velocity (m/s)	Trunk height (mm)	Trunk width (mm)	Trunk area (mm^2)	Trunk Sec. airflow ratio	Noise Test Airflow (L/s)	Noise Test Velocity (m/s)
Second Floor | **ST1**	**153**	**184**	**184**	4.46	203	203	41,290	**100.0%**	**189**	4.57
Second Floor | ST1A	49	66	66	2.12	152	203	30,968	35.6%	67	PASS 2.16
Main Floor | **ST2**	**134**	**178**	**178**	4.32	203	203	41,290	**100.0%**	**189**	4.57
Main Floor | ST2A	80	95	95	3.07	152	203	30,968	53.2%	100	3.23
Basement | **ST3**	**90**	**15**	**90**	2.90	152	203	30,968	**100.0%**	**189**	6.10
Basement | ST3A	54	9	54	2.61	102	203	20,645	60.0%	113	FAIL 5.47
Total	**378**	**378**	**378**							
50% of total system design flow = 189										

Noise Test Airflows: The three zones have design airflows of 390 cfm, 378 cfm, and 190 cfm (184 L/s, 178 L/s and 90L/s). Each of these airflow values is less than 50% of the total system design airflow, which in this example is equal to 400 cfm (189 L/s). As a result, the zone trunks will be evaluated for excessive noise levels using "noise test" airflows of 50% of the total system design airflow or 400 cfm (189 L/s) entering each supply trunk.

Noise Test Airflows after a Trunk Taper: The airflows entering each downstream section of a zone trunk immediately after a taper (e.g. ST1A) will be lower than the “noise test” airflow entering the initial section of the zone trunk (e.g., ST1) as a result of airflows in upstream supply branches. These “downstream test airflows” can be calculated using the **%Trunk airflow** fraction for each of the downstream sections. For example, in imperial units, the %Trunk airflow in Section ST1A is:

%Trunk airflow in Section ST1A = design airflow in ST1A / design airflow in ST1
= 139 cfm / 390 cfm = 35.6%

The “noise test” airflow in trunk section ST1A is calculated as follows:

Noise test airflow in Section ST1A = Noise Test airflow entering ST1 x %Trunk airflow in ST1A
= 400 cfm x 35.6% = 142 cfm

“Noise test” airflow values for the other supply trunk sections are calculated in a similar way and are shown in the second column from the right in Table 5-3 (imperial units) and Table 5-4 (metric units).

Noise Test Air Velocities: The resulting “noise test” air velocity can be calculated in each trunk section using one of the following formulas.

In imperial units, the “noise test” air velocity (fpm) equals “noise test” airflow (cfm) times 144 divided by the “trunk area” (sq-in), or:

fpm = cfm x 144 / sq-in

In metric units, the “noise test” air velocity (m/s) equals “noise test” airflow (L/s) times 1000 divided by the “trunk area” (mm^2), or:

m/s = L/s x 1000 / mm^2

Using these formulas, the “noise test” air velocity in each of the supply trunk sections can be calculated using the “noise test” airflow for each trunk section. The resulting “noise test” air velocities are shown in the right-hand column of in Table 5-3 (imperial units) and Table 5-4 (metric units).

Noise-Test Results:

- **All sections of zone supply trunks 1 and 2 passed** the “noise test” with calculated “noise test” velocities less than or equal to 900 fpm (4.57 m/s) at the “noise-test” conditions.
- **Both sections ST3 and ST3A of zone supply trunk 3 failed** the “noise test” with calculated “noise test” velocities of 1,200 and 1,080 fpm (6.1 and 5.5 m/s) respectively at the “noise-test” conditions.

Final Zone Supply Trunk Design

To remedy the high velocity in zone supply trunk 3 during single-zone operation, the duct sizes should be increased from 6 in by 8 in to 8 in by 8 in (152 mm by 203 mm to 203 mm by 203 mm) for section ST3, and from 4 in by 8 in to 6 in by 8 in (102 mm by 203 mm to 152 mm by 203 mm) for section ST3A.

The final supply trunk design for the example 3-zone HVAC system is summarized in Table 5-5 (imperial units) and Table 5-6 (metric units).

Table 5-5: Example of final supply trunk (ST) design for a 3-zone system which passes the "noise-test" (imperial)

Truck Section Name	Heating airflow (cfm)	Cooling airflow (cfm)	Design airflow (cfm)	Design velocity (fpm)	Trunk height (in.)	Trunk width (in.)	Trunk area (sq-in)	Trunk Sec. airflow ratio (%trunk)	Noise Test Airflow (cfm)	Noise Test Velocity (fpm)
Second Floor | **ST1**	**325**	**390**	**390**	878	8.0	8.0	64.0	**100.0%**	**400**	900
Second Floor | ST1A	104	139	139	417	6.0	8.0	48.0	35.6%	142	426
Main Floor | **ST2**	**285**	**378**	**378**	851	8.0	8.0	64.0	**100.0%**	**400**	900
Main Floor | ST2A	169	201	201	604	6.0	8.0	48.0	53.2%	213	639
Basement | **ST3**	**190**	**32**	**190**	428	8.0	8.0	64.0	**100.0%**	**400**	900
Basement | ST3A	114	19	114	342	6.0	8.0	48.0	60.0%	240	720
Total	**800**	**800**	**800**							
50% of total system design flow = 400										

PASS

Table 5-6: Example of final supply trunk (ST) design for a 3-zone system which passes the "noise-test" (metric)

Trunk Section Name	Heating airflow (L/s)	Cooling airflow (L/s)	Design airflow (L/s)	Design velocity (m/s)	Trunk height (mm)	Trunk width (mm)	Trunk area (mm²)	Trunk Sec. airflow ratio (%trunk)	Noise Test Airflow (L/s)	Noise Test Velocity (m/s)
Second Floor | **ST1**	**153**	**184**	**184**	4.46	203	203	41,290	**100.0%**	**189**	4.57
Second Floor | ST1A	49	66	66	2.12	152	203	30,968	35.6%	67	2.16
Main Floor | **ST2**	**134**	**178**	**178**	4.32	203	203	41,290	**100.0%**	**189**	4.57
Main Floor | ST2A	80	95	95	3.07	152	203	30,968	53.2%	100	3.23
Basement | **ST3**	**90**	**15**	**90**	2.17	203	203	41,290	**100.0%**	**189**	4.57
Basement | ST3A	54	9	54	1.74	152	203	30,968	60.0%	113	3.65
Total	**378**	**378**	**378**							
50% of total system design flow = 189										

PASS

In the final zone supply trunk design, all three zone trunks start at the plenum as 8 in by 8 in (to 203 mm by 203 mm) ducts and taper into 6 in by 8 in (152 mm by 203 mm) ducts in the downstream sections.

5.6 Specify supply-air duct sealing requirements

Ensuring supply ducts are sealed well will promote effective air distribution (conditioned air will get to where it has been designed to go). This practice becomes ever more important as we move towards HVAC equipment sized more closely to design loads.

OPTION A – Standard sealing practices

The mechanical designer should specify that supply ducting be sealed using an approved duct sealing metal-backed tape, mastic compound or gasket and following the Sheet Metal & Air Conditioning Contractor's National Association (SMACNA) "Class C" duct-sealing practices[8] for supply ducts in conditioned spaces and SMACNA "Class A" duct-sealing practices[9] for supply ducts in unconditioned spaces.

OPTION B – Upgrade sealing practices to SMACNA "Class A" throughout

The mechanical designer should specify that all supply duct joints and supply outlet joints be sealed using an approved duct sealing metal-backed tape, mastic compound, or gasket and following the Sheet Metal & Air Conditioning Contractor's National Association (SMACNA) "Class A" duct-sealing practices. This applies for supply ducts in both conditioned and unconditioned spaces.

5.7 Specify supply-air trunk labelling requirements

The mechanical designer should specify supply-trunk labelling requirements to be implemented by the HVAC installer. All zone supply trunks should have identification labels affixed to them near the plenum of the furnace or air handler, with zone designations such as "*Basement*", "*Main Floor*" and "*Second Floor*" or other appropriate descriptors. This labelling will:

- Guide installers on connection of zoned equipment to the zoned ducting system.
- Ensure proper coordination between the zone supply air outlets from the equipment and the corresponding zone thermostats during equipment commissioning.

8 The "Class C" duct-sealing level requires that only transverse joints be sealed (mastics, liquids or gaskets).

9 The "Class A" duct sealing level requires that transverse joints, longitudinal seams and all applicable penetrations be sealed (mastics, liquids or gaskets).

Upon completing STEP 5, you will have:

- ☐ Specified the location, size and type of supply-air outlets in each room.
- ☐ Defined supply duct routing to optimize flow and equivalent lengths.
- ☐ Specified the type of ducting used for supply branches and zone supply trunks
- ☐ Completed preliminary duct sizing for supply branches and zone supply trunks.
- ☐ Checked zone supply trunks for potential excessive velocity/noise levels during single-zone operation and adjusted duct sizes as required.
- ☐ Defined final duct sizes for zone supply trunks to mitigate excessive air velocity/noise during single-zone operation.
- ☐ Specified the supply-duct sealing requirements.
- ☐ Specified the zone supply-trunk labelling requirements.

STEP 6: SPECIFY THERMOSTAT REQUIREMENTS

6.1 Specify thermostat locations

The mechanical designer should specify the location of each zone thermostat on the house floor plans as follows:

- Locate one thermostat per zone.
- Locate the thermostat centrally within each zone.
- Locate the thermostat away from drafts, corners of rooms, heat sources (e.g. supply ducting, lighting dimmer controls inside walls), and direct exposure to sunlight.
- Placed at a height above the floor in keeping with building construction practices using a low-voltage mounting bracket secured to a wall stud to mark the thermostat rough-in locations.

The best practice applications for zone thermostat locations are described in the following paragraphs.

Hallway Thermostat Placement

Applications:

- This is an ideal placement for main floor and basement zones, located away from direct sunlight.
- As an alternative location for upper floor zones, the thermostat can be located near a return air inlet, and should not be near the top of a stairwell as air movement up or down the stairwell can lead to unrepresentative temperature readings.

Alternative upper-floor zone location: Hallway, away from the stairway

Figure 6-1: Hallway Thermostat Placement for a Three-Level Home, Zoned by Floor

Master Bedroom Thermostat Placement

Applications:

- This is the ideal placement for upper floor bedroom zones, or
- Main floor bedroom zones (e.g. in bungalow zoning plans).

In all cases, the designer should ensure that the other rooms serviced on the same zone supply trunk will receive appropriate heating and cooling.

Figure 6-2: Thermostat Placement in the Upper-Floor Master Bedroom

Top-Level Thermostat Placement

Application:

- If a zone contains more than one floor, the zone thermostat should be placed on the top level of the zone as shown in Figure 6-3.

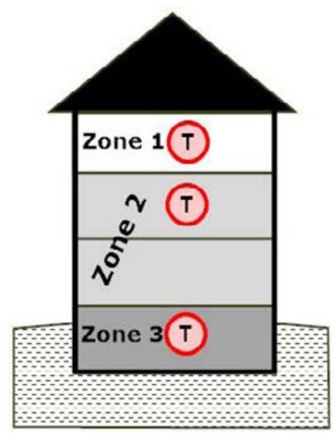


Figure 6-3: Thermostat Placement when a Zone has more than One Floor

6.2 Specify thermostat wiring and labelling requirements

The mechanical designer should specify the thermostat wiring as follows:

- Use only approved low-voltage thermostat wiring (18 AWG minimum, 8-conductor will provide maximum flexibility, 5-conductor minimum).
- Install separate wiring runs from each zone thermostat rough-in location to a central location in the mechanical room with enough extra length to allow connection to the HVAC equipment.

- Label both ends of each set of wires with a unique zone identifier that is consistent with the labels used on the zone supply trunks. For example in a three-zone system, zoned by floor, appropriate labels could be:
  - "*Second Floor*",
  - "*Main Floor*" and
  - "*Basement*".

6.3 Specify thermostat type and installation requirements

The mechanical designer should review the **Zoning Checklist** to confirm the builder's preferences for thermostat type. Possible types are:

A. Programmable Thermostats;

B. Smart Programmable Thermostats; or,

C. Non-Programmable Thermostats.

Once confirmed, the designer should specify the type of thermostat to be installed at each zone thermostat location as part of the installation instructions for the HVAC installer.

Zone-Ready Installations:

In instances when non-zoned equipment is being connected to a Zone-Ready ducting system, the thermostat installation instructions for the HVAC installer should include:

- Installing the preferred thermostat type at the main floor rough-in location, and
- Placing blank cover plates over unused thermostat wires at the other rough-in locations within finished areas of the home.

Upon completing STEP 6, you will have:

☐ Defined and marked the thermostat locations on the ducting plans for each zone in the home.

☐ Specified the type of wiring and the identification labels to be used on each set of thermostat wires, and noted these installation requirements on the ducting plans for the home.

☐ Confirmed the number and type of thermostats to be installed in the home, and noted these installation requirements on the ducting plans for the home.

STEP 7: PREPARE INSTALLATION AND COMMISSIONING NOTES FOR THE HVAC INSTALLER AND TECHNICIAN

In Step 7 the mechanical designer should prepare notes:

- To guide the HVAC installer on the zoned installation.
- To guide the HVAC technician on the start-up, commissioning and setup of the zoned equipment.
- These notes should be attached to the design document as the "final drawing page" as an effective means of ensuring the information is provided to the HVAC installer and technician.

NOTE: In today's world of rapidly changing technology it is challenging to provide information that applies to all types of zoned HVAC equipment and to all installations.

- The following installation and commissioning notes are provided as a broad-based guide only.
- In all cases, the HVAC equipment manufacturers' installation and commissioning guidelines should be strictly adhered to.

7.1 Return Duct Installation Method Notes

Specify either:

A. **Use joist and stud cavities**, supplemented with joist linings, joist block ends and some hard pipe as return branches, terminating in a rectangular return trunk, which is connected to the equipment.

B. **Use a hard-ducted return**, assembled using rigid round, oval or rectangular ducting for both return branch ducts and a return trunk that is connected to the equipment.

7.2 Supply Branch Ducts Installation Notes

A. **All Installations:** Supply branches should be installed using rigid round ducting, with suitable register boots, matched to the specified register diffuser grilles at each supply outlet location. If flexible branch ducts are specified, manufacturers guidelines should be followed.

7.3 Zone Supply Trunks Installation Notes

Specify either:

A. **Install zone supply trunks using rectangular ducting**, with traditional top or side supply takeoffs used to connect to supply branches.

B. **Install zone supply trunks using round or oval ducts**, with matching wye fittings or saddles used to connect to supply branches.

7.4 Supply Branch and Trunk Duct-Sealing Notes

Specify either:

A. **Standard duct-sealing:**

- Seal transverse joints of all supply ducting in conditioned spaces (i.e. SMACNA[10] “Class C” duct-sealing practices);
- Seal transverse joints, longitudinal seams and applicable penetrations of supply ducting located in unconditioned spaces (i.e. SMACNA “Class A” duct-sealing practices).

B. **Upgraded duct-sealing:**

- Seal transverse joints, longitudinal seams and applicable penetrations of supply ducting located in both conditioned and unconditioned spaces (i.e. SMACNA “Class A” duct-sealing practices).

7.5 Supply Trunk Labelling Notes

Zone supply trunks (ST) should have zone identification labels affixed to them near the plenum of the furnace or air handler. Approaches to labelling might include:

Zone supply trunk identification labels for a three-level house, zoned by floor:

- ST1 Label to read: “Second Floor”
- ST2 Label to read: “Main Floor”
- ST3 Label to read “Basement”

10 SMACNA is an acronym for the “Sheet Metal & Air-conditioning Contractor’s National Association”

7.6 Thermostat Wiring Labelling Notes

Zone thermostat wiring should have zone identification labels affixed to both ends of each set of wires with a unique zone identifier that is consistent with the labels used on the zone supply trunks. As such, labelling approaches include:

Zone thermostat wiring identification labels for a three-level house, zoned by floor:

- Upper floor thermostat wiring labels to read: "Second Floor"
- Main floor thermostat wiring labels to read: "Main Floor"
- Basement thermostat wiring labels to read: "Basement"

7.7 Equipment Supply-Trunk Connection Notes

Specify one of the following of supply trunk connections:

A. **Factory Integrated Zoned Equipment:**

- Connect each zone trunk to one of the zone supply outlets on the equipment.
- Any unused supply outlets on the equipment should be closed and sealed using a duct cap.

B. **Site-Assembled Zoned Equipment:**

- Connect each of the zone trunks to the furnace or air-handler supply plenum.
- Install the motorized zone dampers in each zone supply trunk near the equipment supply plenum, before the first branch takeoff.
- Wire each of the motorized zone dampers to the zone controller.

C. **Zoned Ducting with Non-Zoned Equipment (i.e. "*Zone-Ready*"):**

- Connect each zone trunk directly to the furnace or air-handler supply plenum.

7.8 Equipment Commissioning and Airflow Setup Notes

A. **All Installations:** The HVAC technician should commission the HVAC equipment and setup the system airflows in accordance with the manufacturer's instructions for both heating and cooling operation.

7.9 Thermostat Connections and Zone Supply Air Delivery Notes

A. **Zoned Equipment Installations:**

- Install the specified thermostat type in each zone at the specified locations.
- Check that a heating or cooling call from each individual zone thermostat results in the delivery of supply air to all supply outlets in the HVAC zone initiating the call.

B. **Zone-Ready Installations:**

- Install the specified thermostat type at the main floor location only.
- Install blank cover plates over unused thermostat wires in the finished areas of the home.

7.10 Changeover Approach Between Heating and Cooling Mode Notes

If the changeover approach between heating and cooling modes is programmable and not "hard-wired" in the zoning controller, the desired changeover option should be specified in the setup notes as:

A. **Manual changeover**

B. **Automatic changeover**

Upon completing STEP 7, you will have:

- ☐ Prepared return ducting installation notes
- ☐ Prepared supply ducting installation notes
- ☐ Prepared supply duct-sealing notes
- ☐ Prepared zone supply trunk labelling notes
- ☐ Prepared thermostat wiring labelling notes
- ☐ Prepared supply-trunk to equipment connection notes
- ☐ Prepared equipment commissioning and setup notes on:
  - Heating and cooling airflow setup
  - Thermostat connection verification
  - Zoning controller settings for heating / cooling mode changeover (if applicable).

APPENDIX A: WORKED EXAMPLE #1– ZONED DUCT DESIGN USING TRADITIONAL DESIGN PARAMETERS

OVERVIEW

This appendix contains a worked example of using the ***Zoning Duct Design Guide*** to design a complete zoned HVAC system for a new tract-built house.

House Description

The example house used in this duct design is a two-storey, four-bedroom, detached home with a basement. The total heated floor area, including the basement is about 4,256 square-feet or 395 square-metres.

Type of Zoned Duct System Requested by the Builder

In this design example, the builder requested “standard ducting” using traditional design parameters. This approach to zoning will result in minimal changes to the ducting design compared to a conventional, single-zone duct design.

The remaining sections of this appendix provide a step-by-step illustrated example of using the ***Zoning Duct Design Guide*** to design this zoned HVAC system.

STEP 1: RECOMMENDED PREREQUISITES

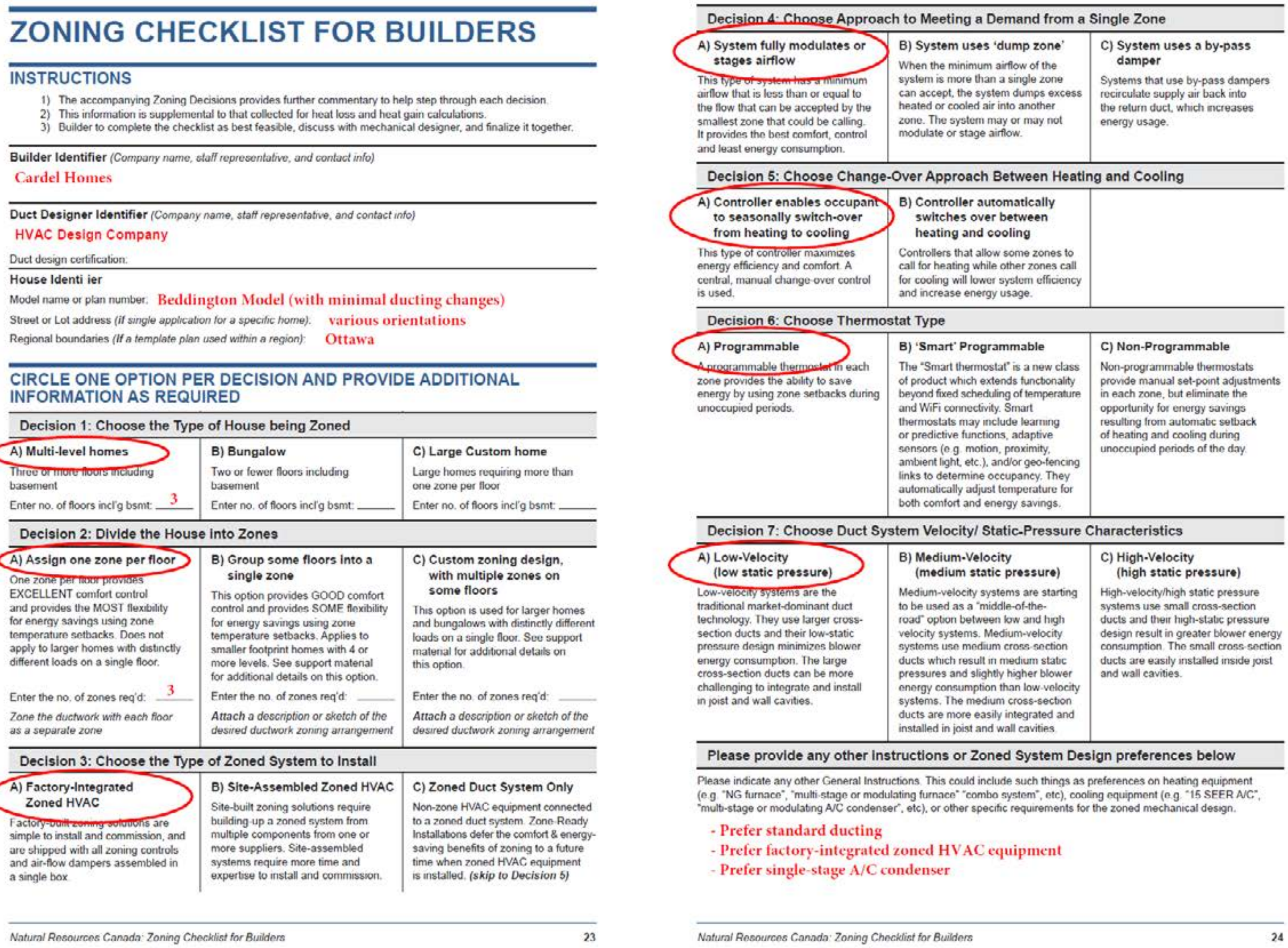
1.1 Experience

As illustrated in Figure A-1, the mechanical designer should have HRAI certification with at least the Residential Heat Loss & Heat Gain (RHLG) and Residential Air Systems Design (RASD) designations, or equivalent certifications.

Figure A-1: Designer Certifications

1.2 Zoning Checklist

The starting point for the zoned duct design guide is a completed **Zoning Checklist** such as the one shown in Figure A-2 which is normally provided by the builder. If the **Checklist** has not been provided, please contact your builder and complete the **Checklist** together by discussing and choosing the most beneficial and appropriate zoning options as the starting point for your zoned duct design.



ZONING CHECKLIST FOR BUILDERS

INSTRUCTIONS

1) The accompanying Zoning Decisions provides further commentary to help step through each decision.
2) This information is supplemental to that collected for heat loss and heat gain calculations.
3) Builder to complete the checklist as best feasible, discuss with mechanical designer, and finalize it together.

Builder Identifier *(Company name, staff representative, and contact info)*
Cardel Homes

Duct Designer Identifier *(Company name, staff representative, and contact info)*
HVAC Design Company

Duct design certification:

House Identi ier

Model name or plan number: Beddington Model (with minimal ducting changes)

Street or Lot address *(if single application for a specific home)*: various orientations

Regional boundaries *(If a template plan used within a region)*: Ottawa

CIRCLE ONE OPTION PER DECISION AND PROVIDE ADDITIONAL INFORMATION AS REQUIRED

Decision 1: Choose the Type of House being Zoned		
A) Multi-level homes Three or more floors including basement. Enter no. of floors incl'g bsmt: 3	**B) Bungalow** Two or fewer floors including basement. Enter no. of floors incl'g bsmt: ____	**C) Large Custom home** Large homes requiring more than one zone per floor. Enter no. of floors incl'g bsmt: ____

Decision 2: Divide the House into Zones		
A) Assign one zone per floor One zone per floor provides EXCELLENT comfort control and provides the MOST flexibility for energy savings using zone temperature setbacks. Does not apply to larger homes with distinctly different loads on a single floor. Enter the no. of zones req'd: 3. *Zone the ductwork with each floor as a separate zone*	**B) Group some floors into a single zone** This option provides GOOD comfort control and provides SOME flexibility for energy savings using zone temperature setbacks. Applies to smaller footprint homes with 4 or more levels. See support material for additional details on this option. Enter the no. of zones req'd: ____ *Attach a description or sketch of the desired ductwork zoning arrangement*	**C) Custom zoning design, with multiple zones on some floors** This option is used for larger homes and bungalows with distinctly different loads on a single floor. See support material for additional details on this option. Enter the no. of zones req'd: ____ *Attach a description or sketch of the desired ductwork zoning arrangement*

Decision 3: Choose the Type of Zoned System to Install		
A) Factory-Integrated Zoned HVAC Factory-built zoning solutions are simple to install and commission, and are shipped with all zoning controls and air-flow dampers assembled in a single box.	**B) Site-Assembled Zoned HVAC** Site-built zoning solutions require building-up a zoned system from multiple components from one or more suppliers. Site-assembled systems require more time and expertise to install and commission.	**C) Zoned Duct System Only** Non-zone HVAC equipment connected to a zoned duct system. Zone-Ready Installations defer the comfort & energy-saving benefits of zoning to a future time when zoned HVAC equipment is installed. ***(skip to Decision 5)***

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Decision 4: Choose Approach to Meeting a Demand from a Single Zone		
A) System fully modulates or stages airflow This type of system has a minimum airflow that is less than or equal to the flow that can be accepted by the smallest zone that could be calling. It provides the best comfort, control and least energy consumption.	**B) System uses 'dump zone'** When the minimum airflow of the system is more than a single zone can accept, the system dumps excess heated or cooled air into another zone. The system may or may not modulate or stage airflow.	**C) System uses a by-pass damper** Systems that use by-pass dampers recirculate supply air back into the return duct, which increases energy usage.

Decision 5: Choose Change-Over Approach Between Heating and Cooling		
A) Controller enables occupant to seasonally switch-over from heating to cooling This type of controller maximizes energy efficiency and comfort. A central, manual change-over control is used.	**B) Controller automatically switches over between heating and cooling** Controllers that allow some zones to call for heating while other zones call for cooling will lower system efficiency and increase energy usage.	

Decision 6: Choose Thermostat Type		
A) Programmable A programmable thermostat in each zone provides the ability to save energy by using zone setbacks during unoccupied periods.	**B) 'Smart' Programmable** The "Smart thermostat" is a new class of product which extends functionality beyond fixed scheduling of temperature and WiFi connectivity. Smart thermostats may include learning or predictive functions, adaptive sensors (e.g. motion, proximity, ambient light, etc.), and/or geo-fencing links to determine occupancy. They automatically adjust temperature for both comfort and energy savings.	**C) Non-Programmable** Non-programmable thermostats provide manual set-point adjustments in each zone, but eliminate the opportunity for energy savings resulting from automatic setback of heating and cooling during unoccupied periods of the day.

Decision 7: Choose Duct System Velocity/ Static-Pressure Characteristics		
A) Low-Velocity (low static pressure) Low-velocity systems are the traditional market-dominant duct technology. They use larger cross-section ducts and their low-static pressure design minimizes blower energy consumption. The large cross-section ducts can be more challenging to integrate and install in joist and wall cavities.	**B) Medium-Velocity (medium static pressure)** Medium-velocity systems are starting to be used as a "middle-of-the-road" option between low and high velocity systems. Medium-velocity systems use medium cross-section ducts which result in medium static pressures and slightly higher blower energy consumption than low-velocity systems. The medium cross-section ducts are more easily integrated and installed in joist and wall cavities.	**C) High-Velocity (high static pressure)** High-velocity/high static pressure systems use small cross-section ducts and their high-static pressure design result in greater blower energy consumption. The small cross-section ducts are easily installed inside joist and wall cavities.

Please provide any other Instructions or Zoned System Design preferences below

Please indicate any other General Instructions. This could include such things as preferences on heating equipment (e.g. "NG furnace", "multi-stage or modulating furnace" "combo system", etc), cooling equipment (e.g. "15 SEER A/C", "multi-stage or modulating A/C condenser", etc), or other specific requirements for the zoned mechanical design.

- Prefer standard ducting
- Prefer factory-integrated zoned HVAC equipment
- Prefer single-stage A/C condenser

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Figure A-2: Example of a completed " **Zoning Checklist**" outlining the "key features selected by the Builder

1.3 Scope of the *zoning duct design guide*

The zoned HVAC design requested by the builder for their house model falls within the scope of the ***Zoning Duct Design Guide***.

Upon completing Step 1, you will have:

☐ Consulted with your builder and obtained or completed a " **Zoning Checklist**", which summarizes the key features of a zoned HVAC system, as the starting point for your design.

STEP 2: DETERMINE HEATING AND COOLING LOADS

2.1 Gather house plans & detailed envelope specifications

The mechanical designer should gather a complete set of construction schematics and other specifications for the particular house model as input to the heat loss and gain calculations and the HVAC system design processes.

The construction schematics for the house model used in this example design are shown in Figures A-3 through A-6.

Figure A-3: Elevation Plan

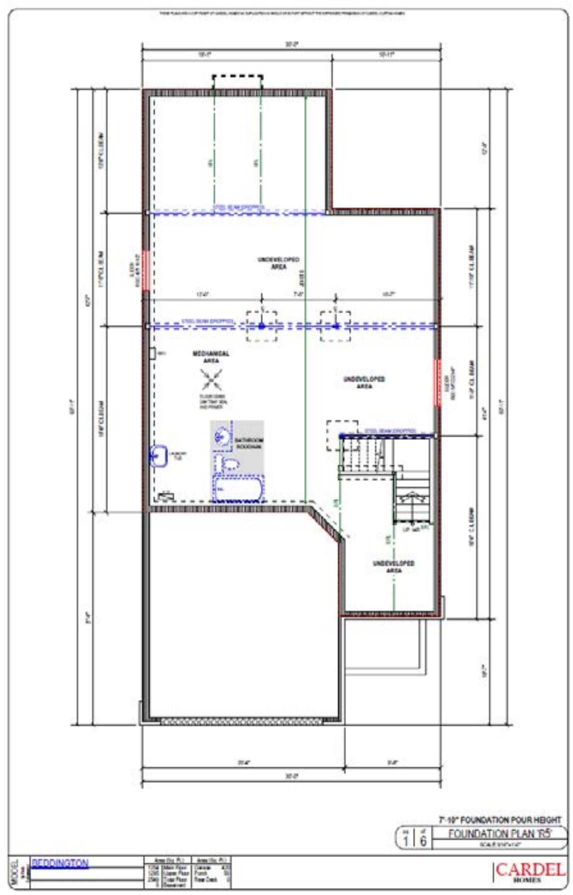


Figure A-4: Basement Floor Plan

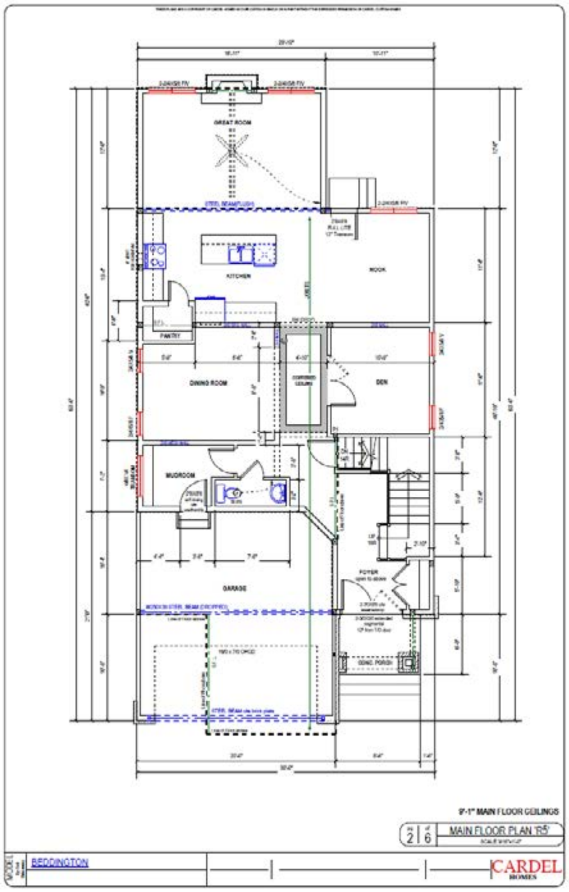


Figure A-5: Main Floor Plan

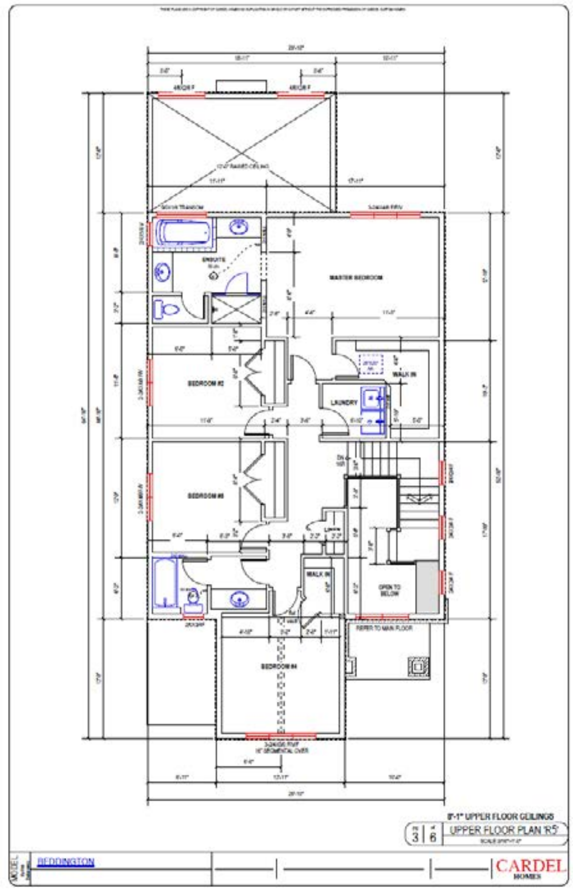


Figure A-6: Second Floor Plan

Window specifications: The window specifications for the house model used in this design example are shown in Table A-1

Table A-1: Window Energy Rating Specifications

Model	Product description	Zone	U value (W/m² ºC)	Solar Heat Gain Coeff.	Energy Rating	NRCan Number
1351	Casement Operator	C	1.66	0.49	32	NR6024-1165221-ES
1351-G	Casement Operator Grille	C	1.71	0.45	29	NR6024-2892269-ES
1352	Casement Fixed	C	1.71	0.49	31	NR6024-1165222-ES
1352-G	Casement Fixed Grille	B	1.77	0.46	28	NR6024-2892270-ES
1353LPF	Picture Window	D	1.68	0.65	41	NR6024-2019493-ES
1306	Basement Window	D	1.77	0.60	35	NR6024-3616956-ES

Air-tightness level: The air tightness level has been based on a prescriptive estimate using the supplemental tool provided by CAN/CSA-F280 Envelope Air Leakage calculator. The specification for this detached home with a finished basement is based on a suburban site with light local shielding. The prescriptive air tightness category selected is “Present” which encompasses typical new homes constructed since 1961. The resulting air tightness value is 3.57 air changes per hour at 50 Pa (ACH50).

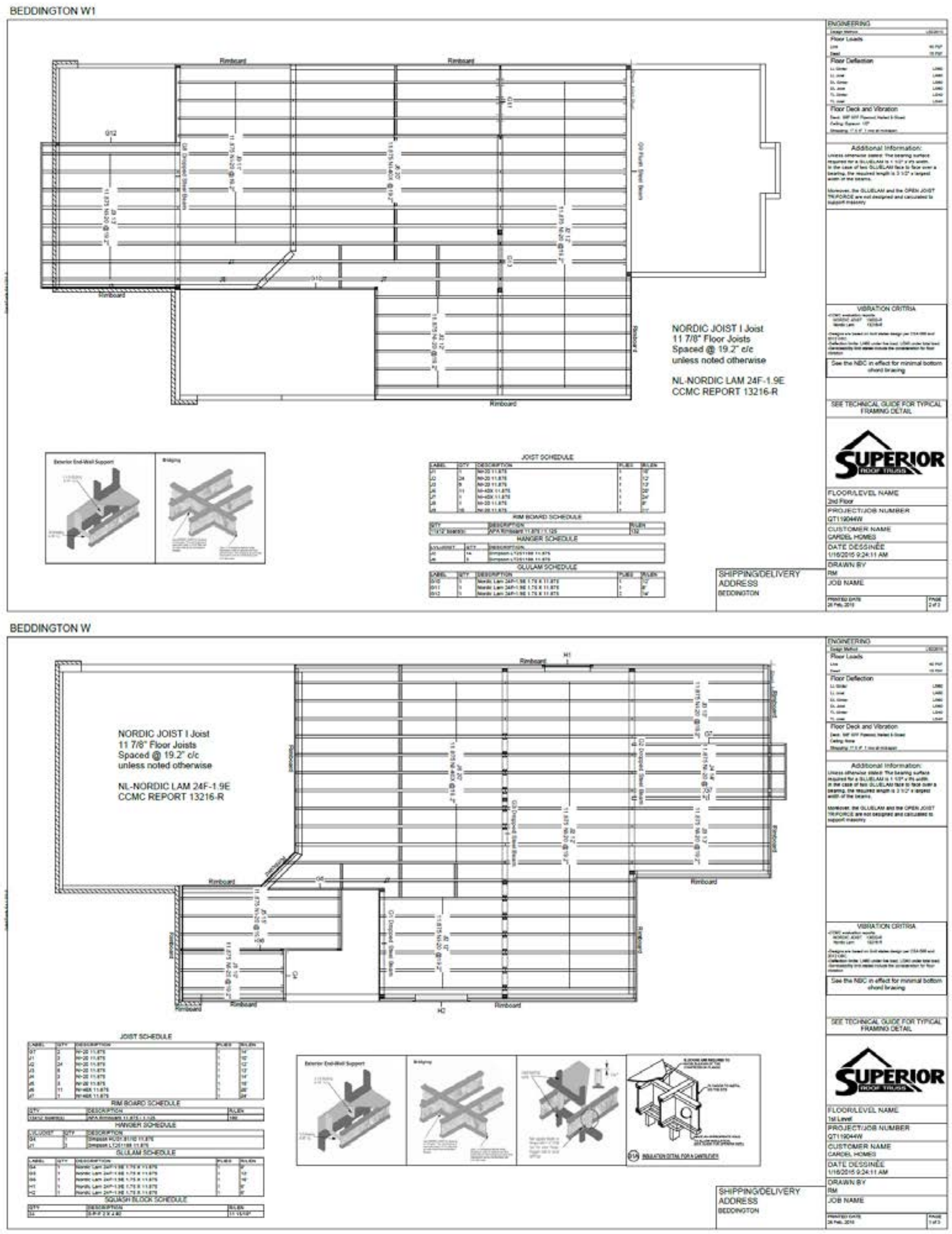


Figure A-7: Joist Plan Details to Assist with HVAC Duct Routing

Joist Plan details: The joist plans for the house model used in this design example are shown in Figure A-7.

2.2 Complete room-by-room heat loss and gain calculations

The mechanical designer should use their normal methodology for heat loss and gain calculations while ensuring CSA F280-12 compliance. The example design presented in this Appendix has been completed using Wrightsoft's Right-F280 HVAC design software as the load calculator. The summary tables shown in the Appendix are representative of the outputs provided by this HVAC design tool.

Table A-2 summarizes the room floor areas together with the calculated heat-loss and heat-gain load values for the house model based on standard weather conditions for the Ottawa region.

Table A-2: Room-by-Room Load Summary Report for the Design Example

ROOM NAME	Area (ft^2)	Area (m^2)	Heating Load (Btuh)	Cooling Load (Btuh)	Heating Load (Watts)	Cooling Load (Watts)
1-Bath	73	6.8	896	829	262	243
1-Bed-2	159	14.8	1,465	1,060	429	311
1-Bed-3	154	14.3	1,827	1,284	535	376
1-Bed-4	201	18.7	3,494	3,281	1,024	961
1-Cavity	370	34.4	2,349	328	688	96
1-Ens-Toil	18	1.7	149	281	44	82
1-Ensuite	109	10.1	973	591	285	173
1-Hall	296	27.5	0	0	0	0
1-Laundry	36	3.3	0	0	0	0
1-Master	252	23.4	2,276	1,866	667	547
1-WIC	85	7.9	807	752	237	220
2-Den	127	11.8	1,265	862	371	253
2-Dining	164	15.2	1,231	1,351	361	396
2-Foyer	186	17.3	1,710	457	501	134
2-Hall	114	10.5	0	0	0	0
2-Kitchen	220	20.4	439	308	129	90
2-Mud	58	5.3	526	447	154	130
2-Nook	121	11.2	1,718	1,758	503	515
2-PWD	23	2.1	190	317	56	93
2-Sun	245	22.8	5,433	4,469	1,592	1,310
3-Basement	1,249	116.0	8,345	853	2,446	250
Sub-Total	4,256	395.4	35,091	21,091	10,284	6,181
Ventilation Load	–	–	6,885	891	2,018	261
Latent cooling	–	–	–	6,595	–	1,933
TOTALS	**4,256**	**395.4**	**41,976**	**28,577**	**12,302**	**8,375**

2.3 Divide the house floor plan into HVAC zones

Using the builder's input from "*Decision #2*" of the **Zoning Checklist**, the mechanical designer should divide the house into individual heating and cooling zones. In this example the builder chose:

OPTION A: Assign one zone per floor including basement

To implement this option, the rooms on each level were grouped into three zones labeled "*basement zone*", "*main floor zone*" and "*second floor zone*" in the HVAC design software using the zoning tree window as shown in the top-left of Figure A-8.

This results in each floor being assigned to a separate zone as confirmed by the different coloured floor plans displayed in the HVAC design software shown in Figure A-8. It should be noted that the conditioned cavity space above the garage ceiling is part of the second-floor zone.

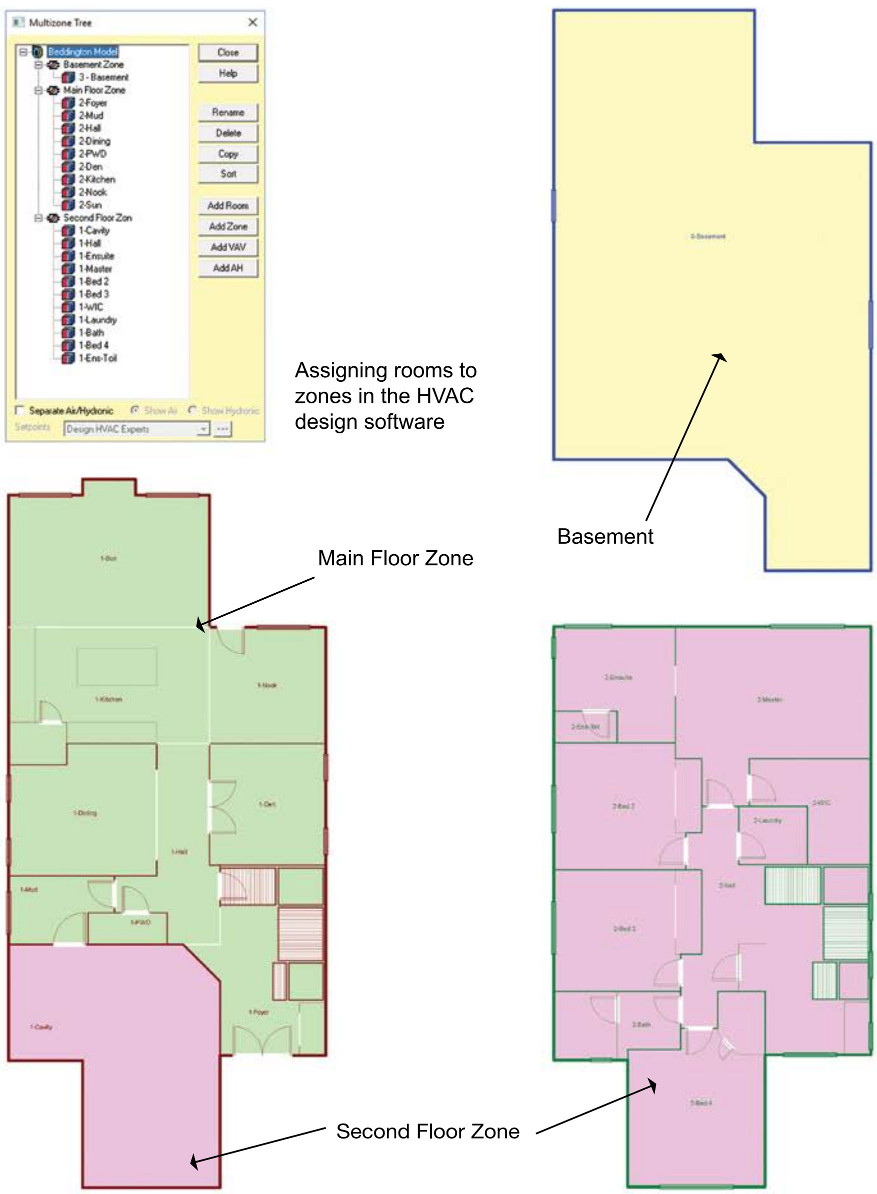


Figure A-8: Example of Floor-by-Floor Zoning using a Software Design Tool

2.4 Determine Zone Heat Loss and Gain Values

Now that the rooms have been grouped into zones, the mechanical designer should calculate the zone-by-zone heat loss and gain values. A summary of the zone heating and cooling load values are provided in Table A-3 for the example design.

Table A-3: Summary of Zone Heating and Cooling Loads for the Example Design

ZONE NAME	Area (ft^2)	Area (m^2)	Heating Load (Btuh)	Cooling Load (Btuh)	Heating Load (Watts)	Cooling Load (Watts)
Second Floor Zone	1,751	162.7	14,235	10,271	4,172	3,010
Main Floor Zone	1,256	116.7	12,511	9,967	3,666	2,921
Basement Zone	1,249	116.0	8,345	853	2,446	250
Sub-Total	4,256	395.4	35,091	21,091	10,284	6,181
Ventilation Load	–	–	6,885	891	2,018	261
Latent cooling	–	–	–	6,595	–	1,933
TOTALS	**4,256**	**395.4**	**41,976**	**28,577**	**12,302**	**8,375**

Testing for Equal Sized Zones

The appropriateness of the zoning plan can be evaluated using the “equal sized” criteria shown in Table A-4 for houses with 2, 3 or 4 HVAC zones. Since this design example has three HVAC zones, the target range for individual zone heating load fractions is 23% to 43%. If the ventilation load is calculated as a separate heat loss and not within each room load then divide the zone heating load by the total heat loss prior to adding in the ventilation load.

For example, the second floor zone heating load fraction is: **14,235 / 35,091 = 41%**

Table A-4: Testing the Zoning Plan for “Equal-Sized” Zones

No. of HVAC Zones (N)	Target Range for “Equal Sized” Individual Zone Heating Loads	Result
2	40% to 60% of total heating load	n/a
3	**23% to 43% of total heating load**	**Second floor zone: 41%** **Main floor zone: 36%** **Basement zone: 24%**
4	15% to 35% of total heating load	n/a

In this example the individual zone heating load fractions range from 24% to 41% and are all within the target range for a three-zone system. In some designs, individual zone values will sometimes fall slightly outside these guideline values, which is acceptable as long as the zone trunk sizes pass the “excessive air velocity / noise level” criteria discussed in Step 5.

Upon completing Step 2, you will have:

- ☐ Confirmed or adjusted the builder’s initially defined zoning approach.
- ☐ Calculated the design heating and cooling loads for the individual zones and the overall house to be used in the equipment selection and sizing in STEP 3.

STEP 3: DEFINE HEATING & COOLING EQUIPMENT REQUIREMENTS

3.1 Choose the air-distribution strategy

The notes under the “*Other Instructions*” section of the **Zoning Checklist** indicate a preference for “standard ducting”. This implies using the “no change from current practice” option, which is:

OPTION A: Traditional Supply Duct Layout

In “*Decision #7*” of the **Zoning Checklist** the builder’s preference of duct system velocity / static pressure characteristic was identified as:

OPTION A: Low Velocity (low static pressure)

Checking the **Decision Matrix** (i.e., Table 3-1 in ***Zoning Duct Design Guide***) this set of options falls within the scope of the ***Zoning Duct Design Guide***, with no restrictions on the type of supply grilles / diffusers that can be used.

3.2 Choose the type of zoned installation

Of the three options available within “*Decision #3*” of the **Zoning Checklist**, the builder selected:

OPTION A: Factory-integrated Zoned HVAC Equipment

To fulfil this requirement, the designer selected a factory-integrated zoned air handler unit (AHU) similar to the unit shown in Figure A-9. This unit is heated by a tankless water heater and cooled by a single-stage air-conditioner as requested by the builder under the “*Other Instructions*” section of the **Zoning Checklist**.

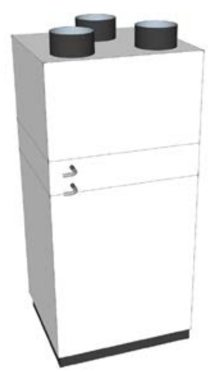


Figure A-9: Example of a Factory-integrated Zoned Air Handler Unit (AHU)

A summary of the heating and cooling equipment specifications are provided in Section 3.5.

3.3 Choose approach to meeting a demand from a single zone

Of the three options available within "*Decision #4*" of the **Zoning Checklist**, the builder selected:

OPTION A: System fully modulates or stages airflow

In this design example, the equipment selected by the designer in Step 3.2 operates as:

OPTION B: System directs airflow to non-calling zones

Small changes to the equipment specification can be expected as the zoned HVAC design is completed. We recommend designers consult with their builders to ensure the final design still meets expectations.

3.4 Choose changeover approach between heating and cooling

The changeover approach selected by the builder in "*Decision #5*" of the **Zoning Checklist** was:

OPTION A: Controller enables occupant to seasonally switch-over from heating to cooling

Factory-integrated zoned equipment, such as the zoned air-handler unit chosen in Step 3.2, have zoning controllers that are "hard-wired" to use the **Option A** changeover approach. No equipment setup is required to select this changeover option.

3.5 Specify the equipment output capacity

As per CSA F280-12 (paragraph 5.3.1) the total capacity of the all heating systems installed in a building shall be not less than 100% of the total building heat loss. This same standard applies to zoned systems. As calculated in Step 2.2, the total heating load is 41,976 Btu/h (12.3 kW). The heating equipment selected has a rated output of **47,700 Btu/h (14.0 kW)**, which is 114% of the calculated heating load.

The recommended guideline for **zoned cooling appliances** is to size equipment output between 80% and 100% of the calculated total equipment cooling load[11], and to not oversize the cooling equipment. As calculated in Step 2.2, the total cooling load is 28,580 Btu/h (8.38 kW). The cooling equipment selected has a rated output of 24,200 Btu/h (7.09 kW), which is 85% of the calculated cooling load.

A complete summary of the heating and cooling equipment selected for this example zoned HVAC design is shown in Table A-5.

11 The sizing guideline for **zoned air-conditioner capacity** is a modification of the HRAI sizing guideline fo**r non-zoned systems**, which recommends air-conditioner condenser capacity of 80% to 125% of total cooling load. See the ***Zoning Duct Design Guide*** document for additional details

Table A-5: Equipment Selection Summary

Heating:			**Cooling:**		
Make: Example Zoned Air Handler			Make: TBD		
Trade: Zoned Air Handler			Trade: TBD		
Model: 3gpm@140F; 14 L/m@60C			Condenser: 2.0 Tons Provision		
Ref: DC Blower			Coil Static Loss: 0.25 in WG 62.5 Pa		
Efficiency	94.0 AFUE	94.0 AFUE	Efficiency	12.0 EER, 14 SEER	
Heating input	50,700 Btuh	14.9 kW	Sensible cooling	18,634 Btuh	5.46 kW
Heating output	47,700 Btuh	14.0 kW	Latent cooling	5,566 Btuh	1.63 kW
Temperature rise	55 °F	31 °C	Total cooling	24,200 Btuh	7.09 kW
Actual air flow	800 cfm	378 L/s	Actual air flow	800 cfm	378 L/s
Air flow factor	0.023 cfm/Btuh	0.037 L/s-W	Air flow factor	0.036 cfm/Btuh	0.061 L/s-W
Static pressure	0.5 in WG	125 Pa	Static pressure	0.5 in WG	125 Pa
			Load sensible heat ratio	0.77	0.77

Upon completing Step 3, you will have:

- ☐ Chosen the Air Distribution Strategy to be implemented in STEP 5;
- ☐ Confirmed or adjusted the builder's selection of operating external static pressure (ESP) for the HVAC system;
- ☐ Confirmed or adjusted the builder's selection of zoned equipment type to be installed;
- ☐ Narrowed the possible suppliers of the zoned equipment based on zoning control features; and,
- ☐ Calculated the required thermal output values for the zoned heating and cooling equipment.

STEP 4: SPECIFY THE RETURN-AIR DUCTING REQUIREMENTS

4.1 Specify return-air duct installation method

The notes under the *"Other Instructions*" section of the **Zoning Checklist** indicate a preference for "standard ducting". This implies using the "no change from current practice" option, which is:

OPTION A: Joist-to-Trunk Return Installation.

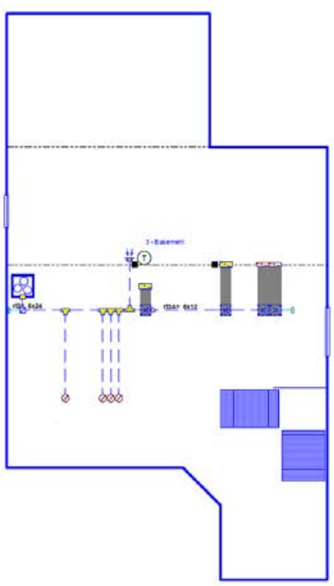
4.2 Specify location of return-air outlets

The notes under the "*Other Instructions*" section of the **Zoning Checklist** indicate a preference for "standard ducting". This implies using the "no change from current practice" option, which is:

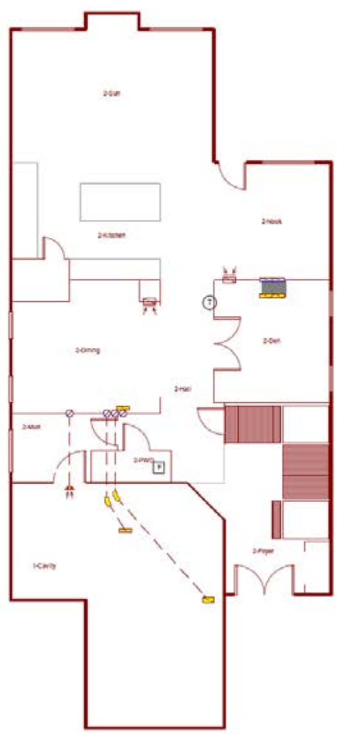
OPTION A: Standard Return Inlet Layout

4.3 Layout return-air ducts

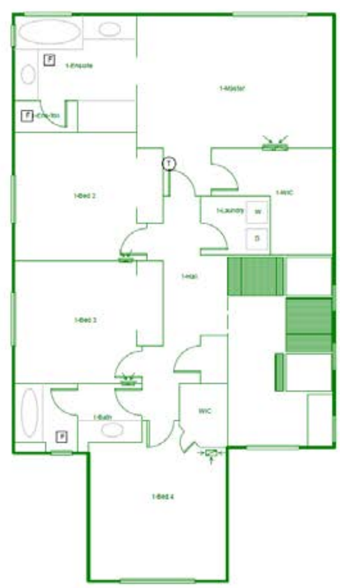
The resulting return-air duct system for the example house model is shown in Figure A-10.



Basement Return Layout



Main Floor Return Layout



Second Floor Return Layout

Figure A-10: Return duct layout for the Example Duct Design

4.4 Specify return-air duct sizing

Tables A-6 and A-7 summarize the duct sizes and relative performance of each individual return branch.

Table A-6: Return Branch (RB) Design Details (Imperial units)

Branch Name	Grill Size (in)	Heating (cfm)	Cooling (cfm)	Equivalent Length (ft)	Design Friction	Velocity (fpm)	Diameter (in)	Height x Width (in)	Duct Material	Connected to
RB1	14x5	148	124	194.5	0.080	278	-	5.50x14	SJSp	RT3A
RB2	14x3	51	77	292.5	0.053	391	6	-	ShMt	RT3
RB3	14x3	76	69	331.0	0.047	388	6	-	ShMt	RT3
RB4	12x3	43	73	357.6	0.043	295	6	-	ShMt	RT3
RB5	14x2	72	58	353.0	0.044	369	6	-	ShMt	RT3
RB6	30x4	217	289	282.5	0.055	424	-	2-3.50x14	SJSp	RT3A
RB8	n/a	54	12	234.3	0.066	273	6	-	ShMt	RT3
RB9	14x5	138	98	370.0	0.042	258	-	5.50x14	SJSp	RT3

Table A-7: Return Branch (RB) Design Details (metric units)

Branch Name	Grill Size (mm)	Heating (L/s)	Cooling (L/s)	Equivalent Length (m)	Design Friction	Velocity (m/s)	Diameter (mm)	Height x Width (mm)	Duct Material	Connected to
RB1	356x127	70	59	59.28	0.651	1.41	-	140x356	SJSp	RT3A
RB2	356x76	24	36	89.16	0.433	1.99	152	-	ShMt	RT3
RB3	356x76	36	33	100.90	0.383	1.97	152	-	ShMt	RT3
RB4	305x76	20	34	109.00	0.354	1.89	152	-	ShMt	RT3
RB5	356x51	34	27	107.60	0.359	1.87	152	-	ShMt	RT3
RB6	762x102	103	136	86.11	0.448	2.16	-	2-89x356	SJSp	RT3A
RB8	n/a	25	6	71.48	0.540	1.39	152	-	ShMt	RT3
RB9	356x127	65	46	112.80	0.342	1.31	-	140x356	SJSp	RT3

Note that return branches RB2, RB3, RB4, RB5 and RB8 are installed as hard-ducted (ShMt) returns while return branches RB1, RB6 and RB9 are installed using the joist-to-trunk (SJSp) installation method.

The return inlet locations are shown in Figure A-10 and are assigned to the zones as follows.

- RB2, RB4, RB5, RB6 and RB8 return air from the second-floor zone (zone 1).
- RB1 and RB9 return air from the main-floor zone (zone 2).
- RB3 returns air from the basement zone (zone 3).

In spite of appearing on the main-floor return layout in Figure A-10, RB8 returns air from the cavity space above the garage ceiling which was assigned to the second-floor zone in Step 2.3.

Tables A-8 and A-9 summarize the duct sizes and relative performance of the corresponding return trunks.

Table A-8: Return Trunk (RT) Design Details (imperial units)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction	Velocity (fpm)	Diameter (in)	Height x Width (in)	Duct Material	Connected to
RT1	Peak AVF	800	800	0.042	480	–	10 x 24	ShMt	equipment
RT3	Peak AVF	800	800	0.042	600	–	8 x 24	ShMt	RT1
RT3A	Peak AVF	366	413	0.055	620	–	8 x 12	ShMt	RT3

Table A-9: Return Trunk (RT) Design Details (metric units)

Trunk Name	Trunk Type	Heating (l/s)	Cooling (l/s)	Design Friction	Velocity (m/s)	Diameter (mm)	Height x Width (mm)	Duct Material	Connected to
RT1	Peak AVF	378	378	0.342	2.44	–	254 x 610	ShMt	equipment
RT3	Peak AVF	378	378	0.342	3.05	–	203 x 610	ShMt	RT1
RT3A	Peak AVF	173	195	0.448	3.15	–	203 x 305	ShMt	RT3

The return air velocities are well within the HRAI maximum velocity guidelines of 650 fpm (3.30 m/s) for return branches and 700 fpm (3.56 m/s) for return trunks.

Upon completing STEP 4, you will have:

- ☐ Specified the location, size and placement of return-air inlets in the home,
- ☐ Defined the return duct routing on the house plans,
- ☐ Specified the size of the return branches and the return trunk ducting,
- ☐ Specified the type of return branch and return trunk ducting and installation method.

STEP 5: SPECIFY THE SUPPLY-AIR DUCTING REQUIREMENTS

5.1 Specify location of supply-air outlets

Following from the Air Distribution Strategy decision made in STEP 3.1, the supply system was designed as a low-velocity, low-pressure duct system using:

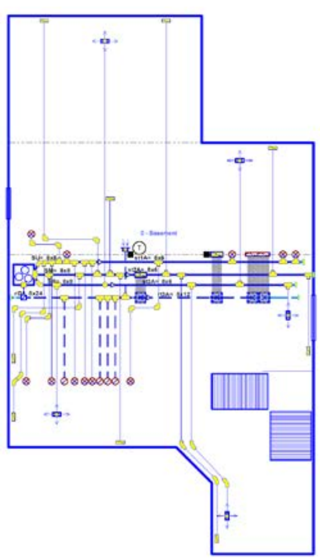
OPTION A – Traditional Supply Duct Layout

5.2 Specify type of ducts used for supply branches

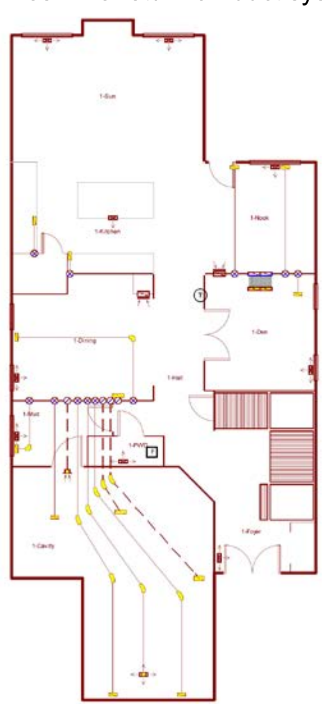
Following the directions from the ***Zoning Duct Design Guide***, the supply branches were designed using rigid, round ducting.

5.3 Layout supply-air ducts

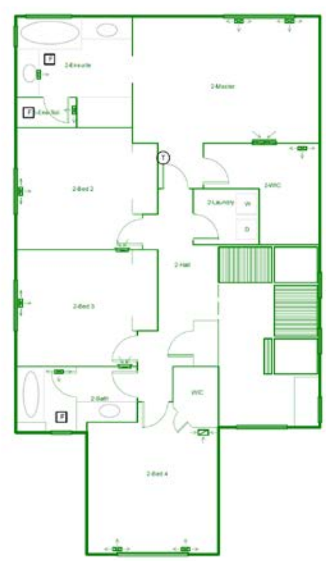
The resulting supply-air duct system shown in Figure A-11 is superimposed on the floor plans for the example house model as solid lines. The return-air duct system is also shown as dashed lines.



Basement Supply Layout



Main Floor Supply Layout



Second Floor Supply Layout

Figure A-11: Supply Duct Layout for the Example Zoned Duct Design

5.4 Specify type of ducts used for the zone supply trunks

The mechanical designer gets to choose either "*Traditional Rectangular*" or "*Round or Oval*" supply trunks. The notes under the "*Other Instructions*" section of the **Zoning Checklist** indicate a preference for "standard ducting". This implies using the "no change from current practice" option, which is:

OPTION A – Traditional Rectangular Ductwork

5.5 Specify supply-air duct sizing

Supply Branch Sizing

When sizing the supply branches the designer should apply HRAI's branch sizing guidelines to ensure each branch is sized accordingly. This means each branch must be able to manage the higher of either heating or cooling airflow and the diameter be sized using either the HRAI or the manufacturer's sizing standards.

Tables A-10 and A-11 summarize the duct sizes and relative performance of each individual supply branch. Each of the supply branches connects to one of the three zone supply trunks.

Table A-10: Supply Branch Duct Design Details (imperial units)

Branch Name	Design (Btuh)	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Diameter (in)	Actual Length (ft)	Fittings Equivalent Length (ft)	Total Equivalent Length (ft)	Connected to
1-Bath	c 829	20	31	0.050	5	35	155	190	ST1
1-Bed-2	c 1060	33	40	0.042	5	54	170	224	ST1A
1-Bed-3	c 1284	42	49	0.042	5	31	195	226	ST1
1-Bed-4	c 1640	40	62	0.048	5	59	140	199	ST1
1-Bed-4-A	c 1640	40	62	0.045	5	56	155	211	ST1
1-Cavity	h 2349	54	12	0.050	6	55	135	190	ST1
1-Ens-Toil	c 281	3	11	0.059	4	16	145	161	ST1
1-Ensuite	c 591	22	22	0.056	4	25	145	170	ST1
1-Master	c 933	26	35	0.057	5	46	120	166	ST1A
1-Master-A	c 933	26	35	0.056	5	41	130	171	ST1A
1-WIC	c 752	18	29	0.064	4	38	110	148	ST1A
2-Den	c 862	29	33	0.083	5	35	80	115	ST2A
2-Dining	c 1351	28	51	0.066	5	19	125	144	ST2
2-Foyer-A	h 1710	39	17	0.059	5	42	120	162	ST2A
2-Kitchen-A	c 308	10	12	0.095	5	15	85	100	ST2
2-Mud	c 444	12	17	0.055	4	18	155	173	ST2
2-Nook	c 1758	39	67	0.075	5	36	90	126	ST2A
2-PWD	c 317	4	12	0.095	4	25	75	100	ST2

Branch Name	Design (Btuh)	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Diameter (in)	Actual Length (ft)	Fittings Equivalent Length (ft)	Total Equivalent Length (ft)	Connected to
2-Sun	h 2235	62	85	0.063	6	37	115	152	ST2
2-Sun-A	h 2235	62	85	0.064	6	38	110	148	ST2A
3-Basement	h 1669	38	6	0.071	5	33	100	133	ST3A
3-Basement-A	h 1669	38	6	0.080	5	29	90	119	ST3A
3-Basement-B	h 1669	38	6	0.078	5	32	90	122	ST3
3-Basement-C	h 1669	38	6	0.056	5	40	130	170	ST3A
3-Basement-D	h 1669	38	6	0.111	5	16	70	86	ST3

Table A-11: Supply Branch Duct Design Details (metric units)

Branch Name	Design (W)	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Diameter (mm)	Actual Length (m)	Fittings Equivalent Length (m)	Total Equiv-alent Length (m)	Connected to
1-Bath	c 243	10	15	0.408	127	11	47	58	ST1
1-Bed-2	c 311	16	19	0.345	127	17	52	68	ST1A
1-Bed-3	c 376	20	23	0.342	127	10	59	69	ST1
1-Bed-4	c 481	19	29	0.388	127	18	43	61	ST1
1-Bed-4-A	c 481	19	29	0.368	127	17	47	64	ST1
1-Cavity	h 688	25	6	0.407	152	17	41	58	ST1
1-Ens-Toil	c 82	2	5	0.482	102	5	44	49	ST1
1-Ensuite	c 173	10	11	0.455	102	8	44	52	ST1
1-Master	c 273	12	17	0.468	127	14	37	50	ST1A
1-Master-A	c 273	12	17	0.454	127	12	40	52	ST1A
1-WIC	c 220	9	13	0.522	102	12	34	45	ST1A
2-Den	c 253	14	15	0.677	127	11	24	35	ST2A
2-Dining	c 396	13	24	0.537	127	6	38	44	ST2
2-Foyer-A	h 501	18	8	0.478	127	13	37	49	ST2A
2-Kitchen-A	c 90	5	6	0.775	127	5	26	30	ST2
2-Mud	c 130	6	8	0.449	102	5	47	53	ST2
2-Nook	c 515	18	31	0.615	127	11	27	38	ST2A
2-PWD	c 93	2	6	0.775	102	8	23	30	ST2
2-Sun	h 655	29	40	0.511	152	11	35	46	ST2
2-Sun-A	h 655	29	40	0.523	152	12	34	45	ST2A
3-Basement	h 489	18	3	0.582	127	10	30	41	ST3A
3-Basement-A	h 489	18	3	0.653	127	9	27	36	ST3A
3-Basement-B	h 489	18	3	0.637	127	10	27	37	ST3
3-Basement-C	h 489	18	3	0.455	127	12	40	52	ST3A
3-Basement-D	h 489	18	3	0.902	127	5	21	26	ST3

Zone Supply Trunk Sizing

Sizing the zone supply trunks is a two part process involving:

1. Preliminary zone trunk sizing based on design airflow requirements,
2. Checking zone trunks for excessive air velocity /noise during single-zone operation.

Preliminary Zone Supply Trunk Sizing based on design airflow requirements

The designer should determine the preliminary sizes of the supply trunks by applying HRAI's sizing guidelines. This means each trunk must be able to manage the higher of either heating or cooling airflow and be sized using either the HRAI or the manufacturer's sizing standards.

Tables A-12 and A-13 summarize the preliminary duct sizes and relative performance of each of the three zone supply trunks.

Table A-12: Preliminary Supply Trunk (ST) Design Details (imperial units)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Velocity (fpm)	Diameter (in)	Height x Width (in)	Duct Material	Connected to
ST1	Peak AVF	325	390	0.042	878	–	8x8	ShMt	–
ST1A	Peak AVF	104	139	0.042	417	–	6x8	ShMt	ST1
ST2	Peak AVF	285	378	0.055	851	–	8x8	ShMt	–
ST2A	Peak AVF	169	201	0.059	604	–	6x8	ShMt	ST2
ST3	Peak AVF	190	32	0.056	570	–	6x8	ShMt	–
ST3A	Peak AVF	114	19	0.056	513	–	4x8	ShMt	ST3
Total	**–**	**800**	**800**	**–**	**–**	**–**	**–**	**–**	**–**

Table A-13: Preliminary Supply Trunk (ST) Design Details (metric units)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Velocity (m/s)	Diameter (mm)	Height x Width (mm)	Duct Material	Connected to
ST1	Peak AVF	153	184	0.342	4.46	–	203x203	ShMt	–
ST1A	Peak AVF	49	66	0.345	2.12	–	152x203	ShMt	ST1
ST2	Peak AVF	135	178	0.449	4.32	–	203x203	ShMt	–
ST2A	Peak AVF	80	95	0.478	3.07	–	152x203	ShMt	ST2
ST3	Peak AVF	90	15	0.455	2.90	–	152x203	ShMt	–
ST3A	Peak AVF	54	9	0.455	2.61	–	102x203	ShMt	ST3
Total	**–**	**378**	**378**	–	–	–	–	–	–

In this design example, each zone trunk has a larger upstream section attached to the equipment plenum, tapering to a smaller downstream section, as follows:

- ST1 and ST1A supply the second floor zone,
- ST2 and ST2a supply the main floor zone, and
- ST3 and ST3A supply the basement zone.

All sections of the zone trunks have supply velocities that are within the HRAI recommendation for a maximum velocity of 900 fpm (4.57 m/s) when all zones are open and operating at design conditions.

Checking zone trunks for excessive air velocity / noise during single-zone operation

The mechanical designer should calculate and check the air velocity in each of the zone supply trunks at a "noise test" condition which simulates single-zone operation.

- Any zone trunk moving 50% or more of the total system design airflow should be "noise tested" at the design airflow for that trunk.
- Any zone trunk moving less than 50% of the total system design airflow should be "noise tested" as if that supply trunk is moving 50% of the total system design airflow at the plenum connection, before any transition, taper or supply branch takeoff.
- If the zone supply trunk includes transitions or tapers to smaller downstream sections, the "noise test" airflow for the downstream sections should be adjusted by the "% trunk airflow fraction" calculated at design airflow conditions for that trunk.

Noise Test Conditions

The design airflows for the three supply trunks, ST1, ST2 and ST3 are 390 cfm, 378 cfm and 190 cfm (184 L/s, 178 L/s and 90 L/s) respectively. Since these values are below 50% of the total system design airflow of 800 cfm (378 L/s), the "noise test" for each of the supply trunks will be evaluated at 50% of the total system design airflow, or 400 cfm (189 L/s) entering each supply trunk.

Noise Test Airflows after a Trunk Taper: The airflows entering each downstream section of a zone trunk immediately after a taper (e.g. ST1A) will be lower than the "noise test" airflow entering the initial section of the zone trunk (e.g., ST1) as a result of airflows in upstream supply branches. These "downstream test airflows" can be calculated using the %Trunk airflow fraction for each of the downstream sections. For example, in imperial units, the %Trunk airflow in Section ST1A is:

%Trunk airflow in Section ST1A = design airflow in ST1A / design airflow in ST1
= 139 cfm / 390 cfm = 35.6%

The "noise test" airflow in trunk section ST1A is calculated as follows:

Noise test airflow in Section ST1A = Noise Test airflow entering the ST1 x %Trunk airflow in ST1A
= 400 cfm x 35.6% = 142 cfm

“Noise test” airflow values for the other supply trunks are calculated in a similar way and are shown in the second column from the right in Table A-14 (imperial units) and Table A-15 (metric units).

Noise Test Air Velocities: The resulting “noise test” air velocity can be calculated in each trunk section using one of the following formulas.

In imperial units, the “noise test” air velocity (fpm) equals “noise test” airflow (cfm) times 144 divided by the “trunk area” (sq-in), or:

$$\textbf{fpm = cfm x 144 / sq-in}$$

In metric units, the “noise test” air velocity (m/s) equals “noise test” airflow (L/s) times 1000 divided by the “trunk area” (mm2), or:

$$\textbf{m/s = L/s x 1000 / mm}^2$$

Noise Test Calculations

Using the preliminary design data from Tables A-12 and A-13, and the formulas described above, the sizing of the supply trunk sections were evaluated at “noise test” conditions which simulate single-zone operation, with the velocity results shown in the right-hand columns of Table A-14 (imperial units) and Table A-15 (metric units).

Table A-14: Testing Supply Trunks (ST) for “noise test” levels (imperial units)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Velocity (fpm)	Height x Width (in)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (cfm)	Noise Test Velocity (fpm)
ST1	Peak AVF	325	390	0.042	878	8x8	–	100%	400	900
ST1A	Peak AVF	104	139	0.042	417	6x8	ST1	36%	143	428 PASS
ST2	Peak AVF	285	378	0.055	851	8x8	–	100%	400	900
ST2A	Peak AVF	169	201	0.059	604	6x8	ST2	53%	213	638
ST3	Peak AVF	190	32	0.056	570	6x8	–	100%	400	1200 FAIL
ST3A	Peak AVF	114	19	0.056	513	4x8	ST3	60%	240	1080
Total	**–**	**800**	**800**							

Table A-15: Testing Supply Trunks (ST) for “noise test” levels (metric units)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Velocity (m/s)	Height x Width (mm)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (L/s)	Noise Test Velocity (m/s)
ST1	Peak AVF	153	184	0.342	4.46	203x203	–	100%	189	4.57
ST1A	Peak AVF	49	66	0.345	2.12	152x203	ST1	36%	68	2.16 PASS
ST2	Peak AVF	135	178	0.449	4.32	203x203	–	100%	189	4.57
ST2A	Peak AVF	80	95	0.478	3.07	152x203	ST2	53%	101	3.23
ST3	Peak AVF	90	15	0.455	2.90	152x203	–	100%	189	6.10 FAIL
ST3A	Peak AVF	54	9	0.455	2.61	102x203	ST3	60%	113	5.47
Total	**–**	**378**	**378**							

Noise-Test Results:

- **All sections of zone supply trunks 1 and 2 passed** the “noise test” with calculated “noise test” velocities less than or equal to 900 fpm (4.57 m/s) at the “noise-test” conditions.
- **Both sections ST3 and ST3A of zone trunk 3 failed** the excessive air velocity/noise test with calculated air velocities of 1,200 and 1,080 fpm (6.10 m/s and 5.47 m/s) respectively at the “noise-test” conditions.

Final Zone Supply Trunk Design

To remedy the high velocity in supply trunk 3 during single-zone operation, section ST3 should be increased to an 8-in by 8-in duct (203 mm by 203 mm), and section ST3A should be increased to a 6-in by 8-in duct (152 mm by 203 mm).

The final supply trunk design for the example 3-zone HVAC system are summarized in Tables A-16 (imperial units) and A-17 (metric units).

Table A-16: Final Supply Trunk (ST) Details, with Increased Sizes to Accommodate Single-Zone Operation (imperial)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Velocity (fpm)	Height x Width (in)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (cfm)	Noise Test Velocity (fpm)
ST1	Peak AVF	325	390	0.042	878	8x8	–	100%	400	900
ST1A	Peak AVF	104	139	0.042	417	6x8	ST1	36%	143	428
ST2	Peak AVF	285	378	0.055	851	8x8	–	100%	400	900
ST2A	Peak AVF	169	201	0.059	604	6x8	ST2	53%	213	638
ST3	Peak AVF	190	32	0.056	428	8x8	–	100%	400	900
ST3A	Peak AVF	114	19	0.056	342	6x8	ST3	60%	240	720
Total		**800**	**800**							

Table A-17: Final Supply Trunk (ST) Details, with Increased Sizes to Accommodate Single-Zone Operation (metric)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Velocity (m/s)	Height x Width (mm)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (L/s)	Noise Test Velocity (m/s)
ST1	Peak AVF	153	184	0.342	4.46	203x203		100%	189	4.57
ST1A	Peak AVF	49	66	0.345	2.12	152x203	ST1	36%	68	2.16
ST2	Peak AVF	135	178	0.449	4.32	203x203		100%	189	4.57
ST2A	Peak AVF	80	95	0.478	3.07	152x203	ST2	53%	101	3.23
ST3	Peak AVF	90	15	0.455	2.17	203x203		100%	189	4.57
ST3A	Peak AVF	54	9	0.455	1.74	152x203	ST3	60%	113	3.65
Total	–	**378**	**378**							

In the final design each of the three zone supply trunks will start at the equipment plenum as an 8-in by 8-in duct (203-mm by 203-mm) and taper to a 6-in by 8-in (152-mm by 203-mm) duct in the downstream section.

5.6 Specify supply-air duct sealing requirements

Being a standard model for a production builder the air sealing requirements chosen are:

OPTION A - Standard sealing practices

5.7 Specify supply-air trunk labelling requirements

Zone trunk identification labels for this three-zone example design are:

- "*Second Floor*" for ST1.
- "*Main Floor*" for ST2 and
- "*Basement*" for ST3.

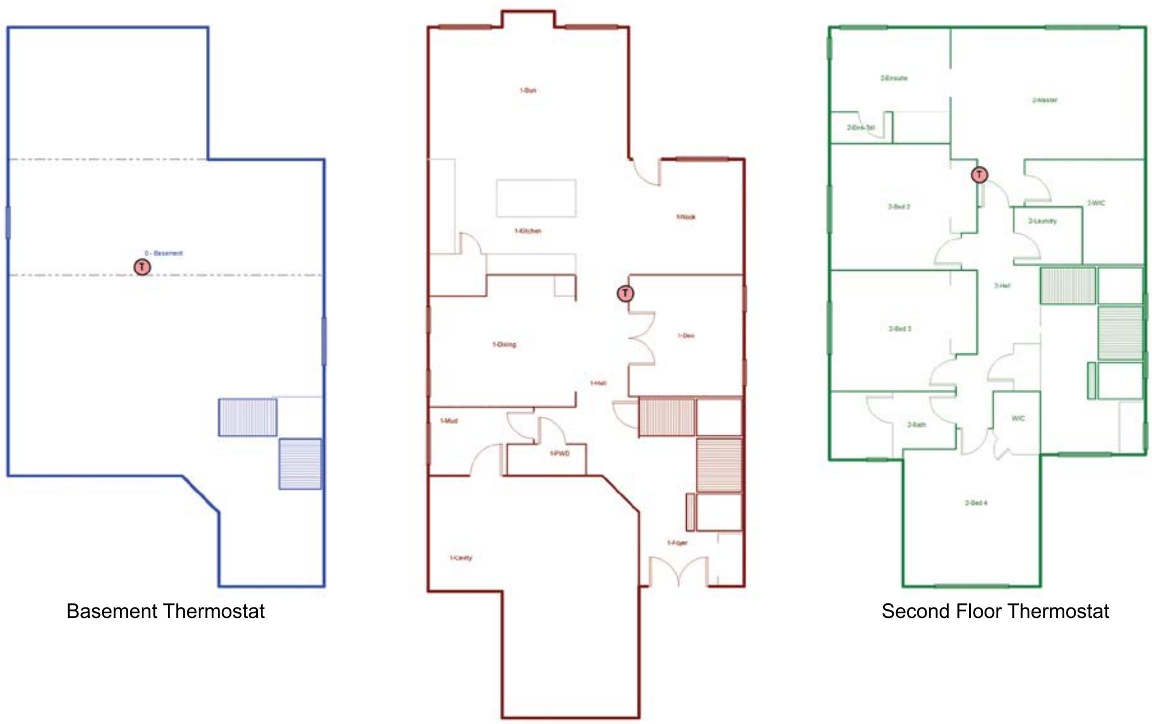
Upon completing STEP 5, you will have:

- ☐ Specified the location, size and type of supply-air outlets in each room.
- ☐ Defined supply duct routing to optimize flow and equivalent lengths.
- ☐ Specified the type of ducting used for supply branches and zone supply trunks.
- ☐ Completed preliminary duct sizing for supply branches and zone supply trunks.
- ☐ Checked zone supply ducting for potential excessive velocity/noise levels during single-zone operation, and adjusted duct sizes as required.
- ☐ Defined the final duct sizes for zone supply trunks to mitigate excessive air velocity/noise during single-zone operation.
- ☐ Specified the supply-duct sealing requirements.
- ☐ Specified the zone supply-trunk labelling requirements.

STEP 6: SPECIFY THERMOSTAT REQUIREMENTS

6.1 Specify thermostat locations

The mechanical designer should specify the location of each zone thermostat on the house floor plans. The best practice applications for zone thermostat locations are described in section 6.1, and are illustrated in Figure A-12 for the example house.



Basement Thermostat

Second Floor Thermostat

Main Floor Thermostat

Figure A-12: Zone Thermostat Locations in the Example Three-Zone HVAC Design

6.2 Specify thermostat wiring and labelling requirements

The mechanical designer should specify thermostat wiring as defined in section 6.2 and require wiring labels on both ends of each set of wires with a unique zone identifier consistent with the labels used on the zone supply trunks. In this three-zone system, zoned by floor, the labels would be:

- "*Basement*",
- "*Main Floor*" and
- "*Second Floor*"

6.3 Specify thermostat type and installation requirements

As selected by the builder within the **Zoning Checklist**:

Option A: Programmable Thermostats

Upon completing STEP 6, you will have:

- ☐ Defined and marked the thermostat locations on the house plans for each zone in the home.
- ☐ Specified the type of wiring and the identification labels to be used on each set of thermostat wires, and noted these installation requirements on the ducting plans for the home.
- ☐ Confirmed the number and type of thermostats to be installed in the home, and noted these installation requirements on the ducting plans for the home.

STEP 7: PREPARE INSTALLATION AND COMMISSIONING NOTES FOR THE HVAC INSTALLER AND TECHNICIAN

NOTE: In today's world of rapidly changing technology it is challenging to provide information that applies to all types of zoned HVAC equipment and to all installations.

- The following installation and commissioning notes are provided as a broad-based guide only.
- In all cases, the HVAC equipment manufacturers' installation and commissioning guidelines should be strictly adhered to.

Possible options for installation and commissioning notes are described in STEP 7 of the ***Zoning Duct Design Guide***.

The applicable installation and commissioning notes for this example duct design were copied and pasted onto a drawing template and attached as a DRAWING PAGE in the duct design as shown in Figure A-13.

Zoned Duct Design

INSTALLATION AND COMMISSIONING NOTES FOR THE HVAC INSTALLER AND TECHNICIAN

7.1 Return Duct Installation Method Notes
A. Use joist and stud cavities, as return branches, supplemented with hard pipe returns. Return branches are then terminated in a rectangular return trunk that is connected to the equipment.

7.2 Supply Branch Ducts Installation Notes
A. All Installations: Supply branches should be installed using rigid round ducting, with suitable register boots, matched to the specified register diffuser grilles at each supply outlet location.

7.3 Zone Supply Trunks Installation Notes
A. Install zone supply trunks using rectangular ducting, with traditional top or side supply takeoffs used to connect to supply branches.

7.4 Supply Branch and Trunk Duct-Sealing Notes
A. Standard duct-sealing:
• Seal transverse joints of all supply ducting in conditioned spaces (i.e. SMACNA "Class C" duct-sealing practices);

7.5 Supply Trunk Labelling Notes
A. Zone identification labels for a three-level house, zoned by floor:
• ST1 Label to read: "Second Floor"
• ST2 Label to read: "Main Floor"
• ST3 Label to read: "Basement"

7.6 Thermostat Wiring Labelling Notes
A Zone identification labels for a three-level house, zoned by floor:
• Upper floor thermostat wiring labels to read: "Second Floor"
• Main floor thermostat wiring labels to read: "Main Floor"
• Basement thermostat wiring labels to read: "Basement"

7.7 Equipment Supply-Trunk Connection Notes
A Factory Integrated Zoned Equipment:
• Connect each zone trunk to one of the zone supply outlets on the equipment.
• Any unused supply outlets on the equipment should be closed and sealed using a duct cap.

7.8 Equipment Commissioning and Airflow Setup Notes
A. All Installations: The HVAC technician is instructed to commission the HVAC equipment and setup the system airflows in accordance with the manufacturer's instructions for both heating and cooling operation.

7.9 Thermostat Connections and Zone Supply Air Delivery Notes
A. Zoned Equipment Installations:
• Install programmable thermostats in each zone at the specified locations.
• Check that a heating or cooling call from each individual zone thermostat results in the delivery of supply air to all supply outlets in the HVAC zone initiating the call.

Notes:

No. of Branches	S/A	R/A	Fans
3rd Floor:			
2nd Floor:			
1st Floor:			
Basement:			

Revision 1:	27-May-2015
Revision 2:	
Builder:	Cardel Homes
Contractor:	TBD
Project:	FOOTPRINT **Boddington Model**
Drawing Title:	Project Notes
Scale: 3/16" = 1'0"	DWG NO. **M0**
Date: 6-May-2015	

Figure A-13: Installation and Commissioning Notes for the Zoned HVAC Design

Upon completing STEP 7, you will have:

- ☐ Prepared return ducting installation notes.
- ☐ Prepared supply ducting installation notes.
- ☐ Prepared supply duct-sealing notes.
- ☐ Prepared zone supply trunk labelling notes.
- ☐ Prepared thermostat wiring labelling notes.
- ☐ Prepared supply-trunk to equipment connection notes.
- ☐ Prepared equipment commissioning and setup notes on:
  - Heating and cooling airflow setup,
  - Thermostat connection verification,
  - Zoning controller settings for heating / cooling mode changeover (if applicable).

APPENDIX B: WORKED EXAMPLE #2 – ZONED DUCT DESIGN USING OPTIONAL DESIGN PARAMETERS

OVERVIEW

This appendix contains a worked example of using the ***Zoning Duct Design Guide*** to design a complete zoned HVAC system for a new tract-built house.

House Description:

The example house used in this duct design is a two-storey, four-bedroom, detached home with a basement. The total floor area, including the basement is about 4,256 square-feet or 395 square-metres.

Type of Zoned Duct System Requested by the Builder

In this design example, the builder requested a number of optional upgrades to the ducting system. These include:

- Centrally located high-wall supply registers, with upgraded duct sealing,
- Simplified return air system installed using hard ducting.

This design approach is a departure from the traditional perimeter system and will result in a ducting system with reduced branch lengths.

The remaining sections of this appendix provide a step-by-step illustrated example of using the ***Zoning Duct Design Guide*** to design this zoned HVAC system.

STEP 1: RECOMMENDED PREREQUISITES

1.1 Experience

As illustrated in Figure B-14, the mechanical designer should have HRAI certification with at least the Residential Heat Loss & Heat Gain (RHLG) and Residential Air Systems Design (RASD) designations, or equivalent certifications.

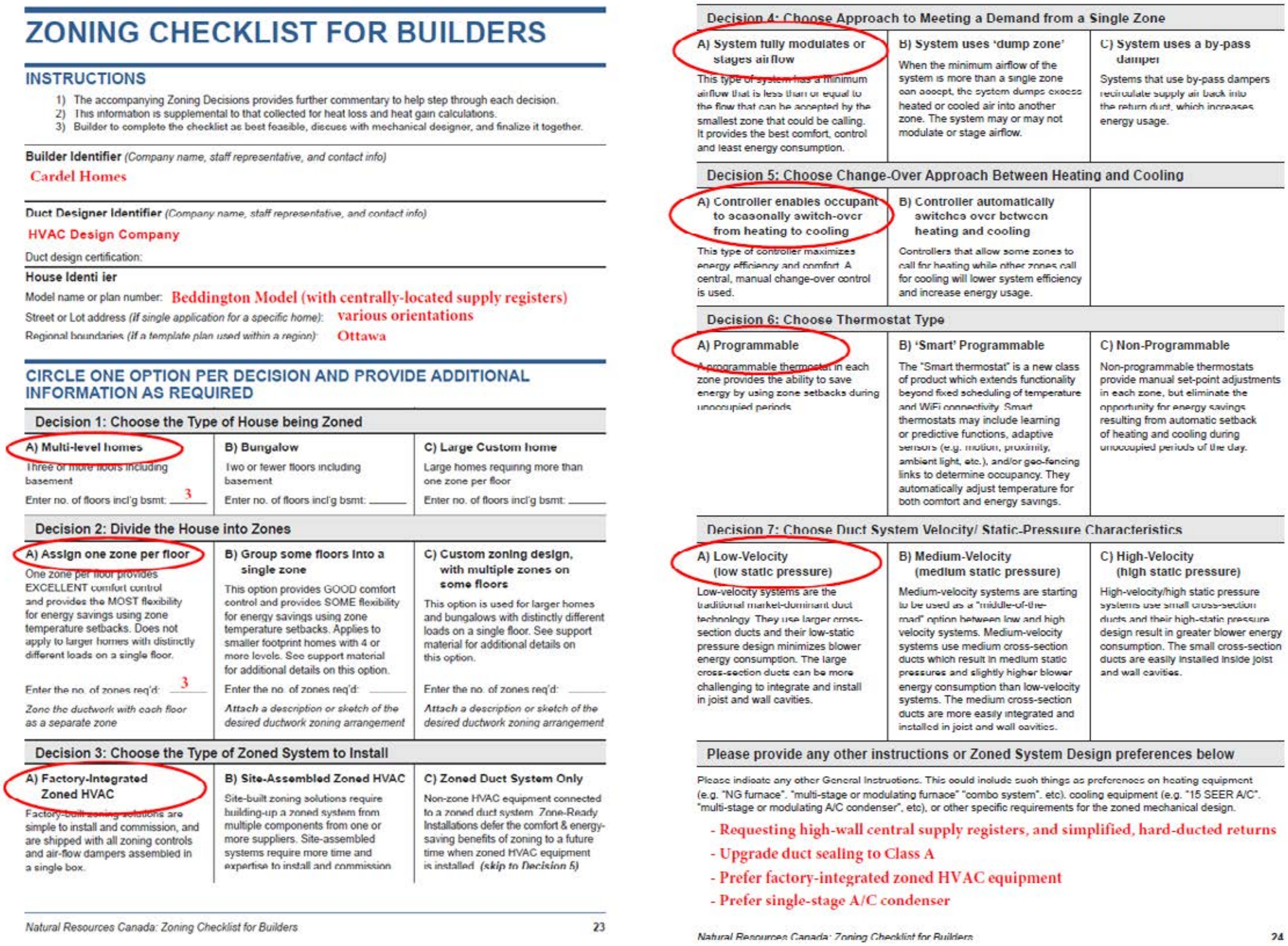
Figure B-14: Designer Certifications

1.2 Zoning Checklist

The starting point for the zoned duct design guide is a completed **Zoning Checklist** such as the one shown in Figure B-15 which is normally provided by the builder. If the **Checklist** has not been provided, please contact your builder and complete the **Checklist** together by discussing and choosing the most beneficial and appropriate zoning options as the starting point for your zoned duct design.

1.3 Scope of the *zoning duct design guide*

The zoned HVAC design requested by the builder for their house model falls within the scope of the ***Zoning Duct Design Guide***.



ZONING CHECKLIST FOR BUILDERS

INSTRUCTIONS

1) The accompanying Zoning Decisions provides further commentary to help step through each decision.
2) This information is supplemental to that collected for heat loss and heat gain calculations.
3) Builder to complete the checklist as best feasible, discuss with mechanical designer, and finalize it together.

Builder Identifier *(Company name, staff representative, and contact info)*

Cardel Homes

Duct Designer Identifier *(Company name, staff representative, and contact info)*

HVAC Design Company

Duct design certification:

House Identi ier

Model name or plan number: Beddington Model (with centrally-located supply registers)

Street or Lot address *(if single application for a specific home)*: various orientations

Regional boundaries *(if a template plan used within a region)*: Ottawa

CIRCLE ONE OPTION PER DECISION AND PROVIDE ADDITIONAL INFORMATION AS REQUIRED

Decision 1: Choose the Type of House being Zoned		
A) Multi-level homes Three or more floors including basement. Enter no. of floors incl'g bsmt: 3	B) Bungalow Two or fewer floors including basement. Enter no. of floors incl'g bsmt: ____	C) Large Custom home Large homes requiring more than one zone per floor. Enter no. of floors incl'g bsmt: ____

Decision 2: Divide the House into Zones		
A) Assign one zone per floor One zone per floor provides EXCELLENT comfort control and provides the MOST flexibility for energy savings using zone temperature setbacks. Does not apply to larger homes with distinctly different loads on a single floor. Enter the no. of zones req'd: 3. *Zone the ductwork with each floor as a separate zone*	B) Group some floors into a single zone This option provides GOOD comfort control and provides SOME flexibility for energy savings using zone temperature setbacks. Applies to smaller footprint homes with 4 or more levels. See support material for additional details on this option. Enter the no. of zones req'd: ____ *Attach a description or sketch of the desired ductwork zoning arrangement*	C) Custom zoning design, with multiple zones on some floors This option is used for larger homes and bungalows with distinctly different loads on a single floor. See support material for additional details on this option. Enter the no. of zones req'd: ____ *Attach a description or sketch of the desired ductwork zoning arrangement*

Decision 3: Choose the Type of Zoned System to Install		
A) Factory-Integrated Zoned HVAC Factory-built zoning solutions are simple to install and commission, and are shipped with all zoning controls and air-flow dampers assembled in a single box.	B) Site-Assembled Zoned HVAC Site-built zoning solutions require building-up a zoned system from multiple components from one or more suppliers. Site-assembled systems require more time and expertise to install and commission.	C) Zoned Duct System Only Non-zone HVAC equipment connected to a zoned duct system. Zone-Ready Installations defer the comfort & energy-saving benefits of zoning to a future time when zoned HVAC equipment is installed. *(skip to Decision 5)*

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Decision 4: Choose Approach to Meeting a Demand from a Single Zone		
A) System fully modulates or stages airflow This type of system has a minimum airflow that is less than or equal to the flow that can be accepted by the smallest zone that could be calling. It provides the best comfort, control and least energy consumption.	B) System uses 'dump zone' When the minimum airflow of the system is more than a single zone can accept, the system dumps excess heated or cooled air into another zone. The system may or may not modulate or stage airflow.	C) System uses a by-pass damper Systems that use by-pass dampers recirculate supply air back into the return duct, which increases energy usage.

Decision 5: Choose Change-Over Approach Between Heating and Cooling		
A) Controller enables occupant to seasonally switch-over from heating to cooling This type of controller maximizes energy efficiency and comfort. A central, manual change-over control is used.	B) Controller automatically switches over between heating and cooling Controllers that allow some zones to call for heating while other zones call for cooling will lower system efficiency and increase energy usage.	

Decision 6: Choose Thermostat Type		
A) Programmable A programmable thermostat in each zone provides the ability to save energy by using zone setbacks during unoccupied periods.	B) 'Smart' Programmable The "Smart thermostat" is a new class of product which extends functionality beyond fixed scheduling of temperature and WiFi connectivity. Smart thermostats may include learning or predictive functions, adaptive sensors (e.g. motion, proximity, ambient light, etc.), and/or geo-fencing links to determine occupancy. They automatically adjust temperature for both comfort and energy savings.	C) Non-Programmable Non-programmable thermostats provide manual set-point adjustments in each zone, but eliminate the opportunity for energy savings resulting from automatic setback of heating and cooling during unoccupied periods of the day.

Decision 7: Choose Duct System Velocity/ Static-Pressure Characteristics		
A) Low-Velocity (low static pressure) Low-velocity systems are the traditional market-dominant duct technology. They use larger cross-section ducts and their low-static pressure design minimizes blower energy consumption. The large cross-section ducts can be more challenging to integrate and install in joist and wall cavities.	B) Medium-Velocity (medium static pressure) Medium-velocity systems are starting to be used as a "middle-of-the-road" option between low and high velocity systems. Medium-velocity systems use medium cross-section ducts which result in medium static pressures and slightly higher blower energy consumption than low-velocity systems. The medium cross-section ducts are more easily integrated and installed in joist and wall cavities.	C) High-Velocity (high static pressure) High-velocity/high static pressure systems use small cross-section ducts and their high-static pressure design result in greater blower energy consumption. The small cross-section ducts are easily installed inside joist and wall cavities.

Please provide any other instructions or Zoned System Design preferences below

Please indicate any other General Instructions. This could include such things as preferences on heating equipment (e.g. "NG furnace", "multi-stage or modulating furnace" "combo system", etc), cooling equipment (e.g. "15 SEER A/C", "multi-stage or modulating A/C condenser", etc), or other specific requirements for the zoned mechanical design.

- Requesting high-wall central supply registers, and simplified, hard-ducted returns
- Upgrade duct sealing to Class A
- Prefer factory-integrated zoned HVAC equipment
- Prefer single-stage A/C condenser

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Figure B-15: Example of a completed " **Zoning Checklist**" outlining the "key features selected by the Builder

Upon completing Step 1, you will have:

☐ Consulted with your builder and obtained or completed a " **Zoning Checklist**", which summarizes the key features of a zoned HVAC system, as the starting point for your design.

STEP 2: DETERMINE HEATING AND COOLING LOADS

2.1 Gather house plans & detailed envelope specifications

The mechanical designer should gather a complete set of construction schematics and other specifications for the particular house model as input to the heat loss and gain calculations and the HVAC system design processes.

The construction schematics for the house model used in this example design are shown in Figures B-16 through B-19.

Figure B-16: Elevation Plan

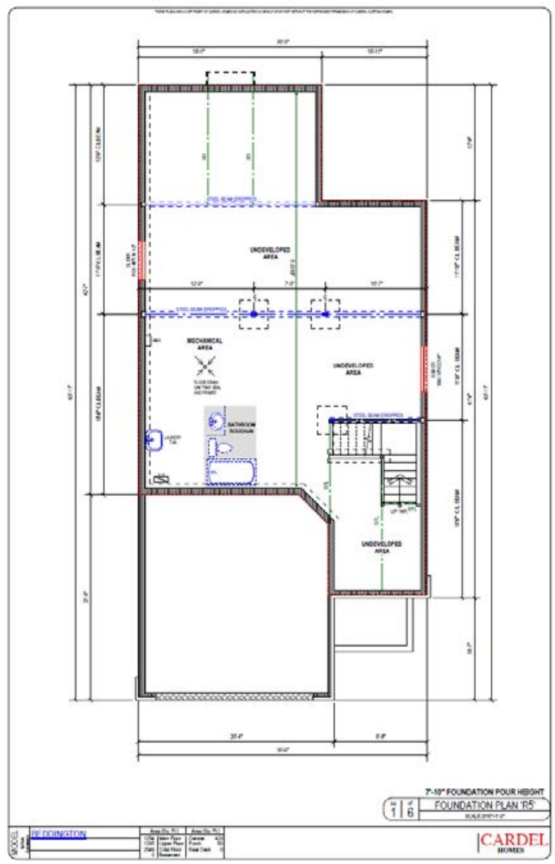


Figure B-17: Basement Floor Plan

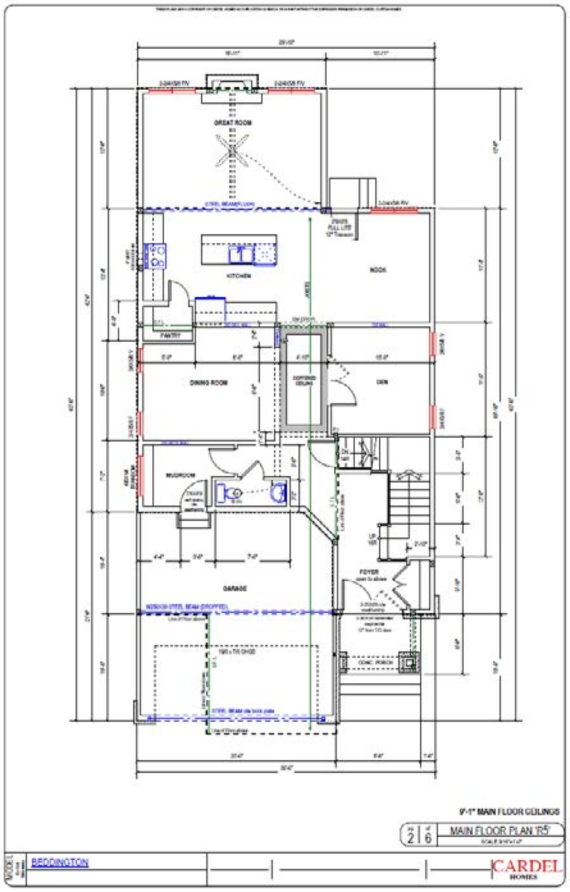


Figure B-18: Main Floor Plan

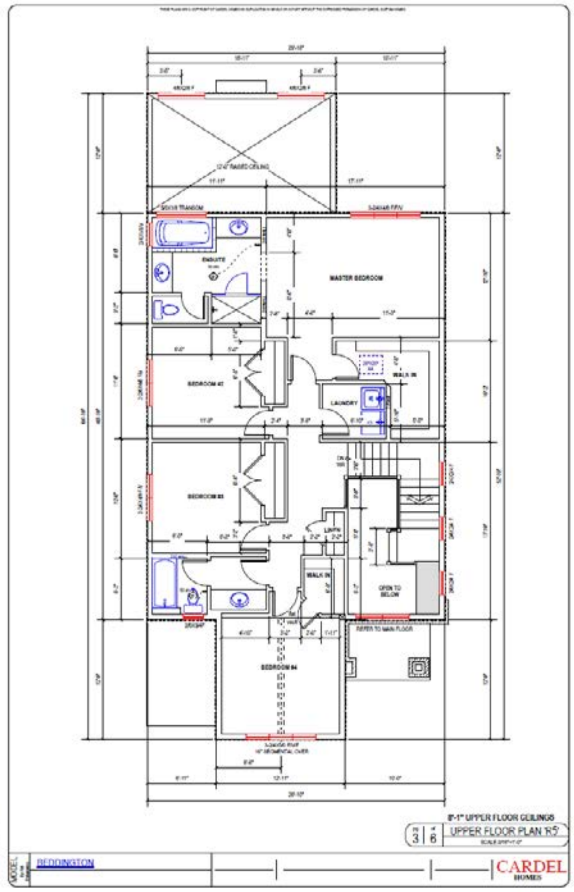


Figure B-19: Second Floor Plan

Window specifications: The window specifications for the house model used in this design example are shown in Table B-18.

Table B-18: Window Energy Rating Specifications

Model	Product description	Zone	U value (W/m² ºC)	Solar Heat Gain Coeff.	Energy Rating	NRCan Number
1351	Casement Operator	C	1.66	0.49	32	NR6024-1165221-ES
1351-G	Casement Operator Grille	C	1.71	0.45	29	NR6024-2892269-ES
1352	Casement Fixed	C	1.71	0.49	31	NR6024-1165222-ES
1352-G	Casement Fixed Grille	B	1.77	0.46	28	NR6024-2892270-ES
1353LPF	Picture Window	D	1.68	0.65	41	NR6024-2019493-ES
1306	Basement Window	D	1.77	0.60	35	NR6024-3616956-ES

Air-tightness level: The air tightness level has been based on a prescriptive estimate using the supplemental tool provided by CAN/CSA-F280 Envelope Air Leakage calculator. The specification for this detached home with a finished basement is based on a suburban site with light local shielding. The prescriptive air tightness category selected is "Present" which encompasses typical new homes constructed since 1961. The resulting air tightness value is 3.57 air changes per hour at 50 Pa (ACH50).

Joist Plan details: The joist plans for the house model used in this design example are shown in Figure B-20.

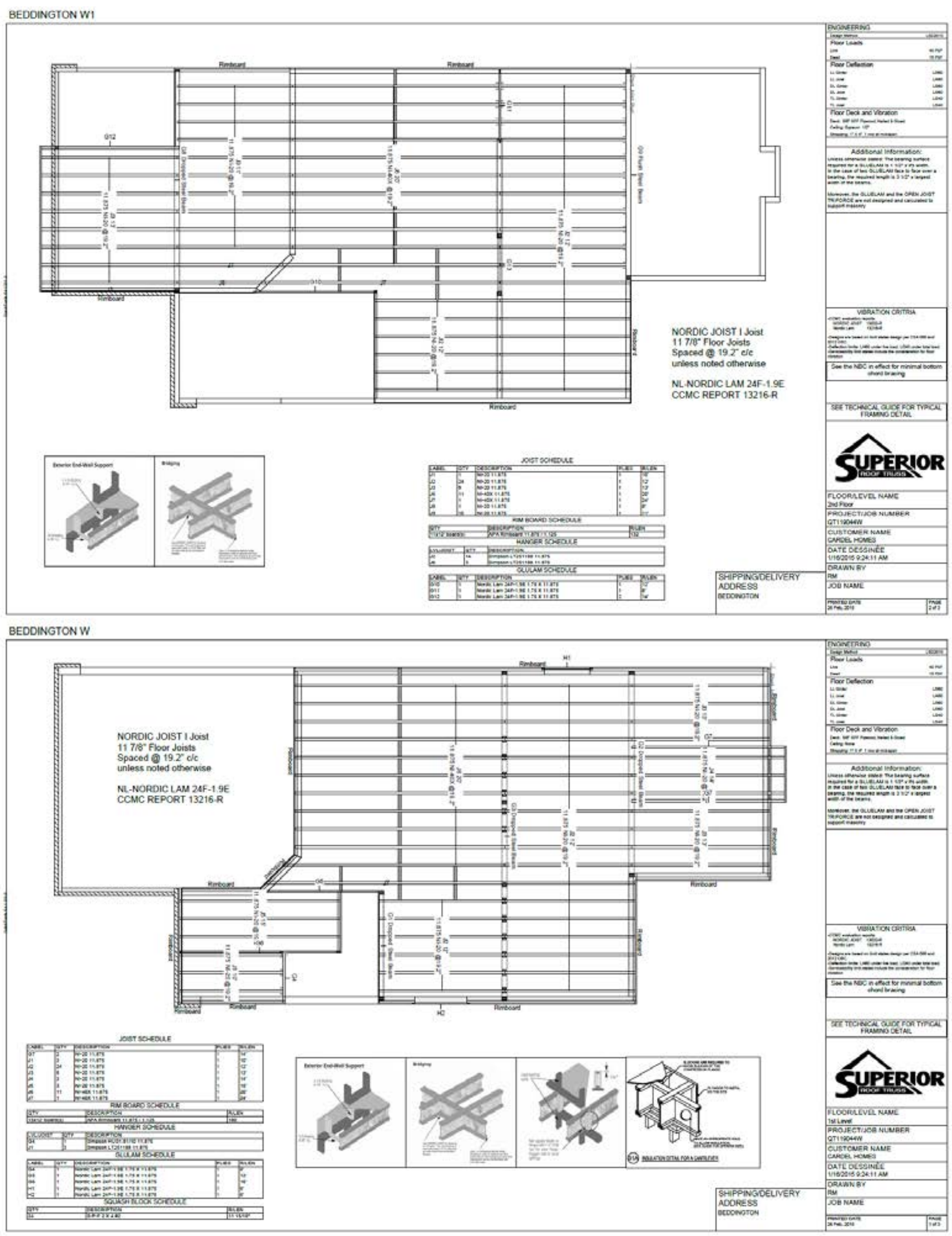


Figure B-20: Joist Plan Details to Assist with HVAC Duct Routing

2.2 Complete room-by-room heat loss and gain calculations

The mechanical designer should use their normal methodology for heat loss and gain calculations while ensuring CSA F280-12 compliance. The example design presented in this appendix has been completed using Wrightsoft's Right-F280 HVAC design software as the load calculator. The summary tables shown in the appendix are representative of the outputs provided by this HVAC design tool.

Table B-19 summarizes the room floor areas together with the calculated heat-loss and heat-gain load values for the house model based on standard weather conditions for the Ottawa region.

Table B-19: Room-by-Room Load Summary Report for the Design Example

ROOM NAME	Area (ft^2)	Area (m^2)	Heating Load (Btuh)	Cooling Load (Btuh)	Heating Load (Watts)	Cooling Load (Watts)
1-Bath	73	6.8	896	829	262	243
1-Bed-2	159	14.8	1,465	1,060	429	311
1-Bed-3	154	14.3	1,827	1,284	535	376
1-Bed-4	201	18.7	3,494	3,281	1,024	961
1-Cavity	370	34.4	2,349	328	688	96
1-Ens-Toil	18	1.7	149	281	44	82
1-Ensuite	109	10.1	973	591	285	173
1-Hall	296	27.5	0	0	0	0
1-Laundry	36	3.3	0	0	0	0
1-Master	252	23.4	2,276	1,866	667	547
1-WIC	85	7.9	807	752	237	220
2-Den	127	11.8	1,265	862	371	253
2-Dining	164	15.2	1,231	1,351	361	396
2-Foyer	186	17.3	1,710	457	501	134
2-Hall	114	10.5	0	0	0	0
2-Kitchen	220	20.4	439	308	129	90
2-Mud	58	5.3	526	447	154	130
2-Nook	121	11.2	1,718	1,758	503	515
2-PWD	23	2.1	190	317	56	93
2-Sun	245	22.8	5,433	4,469	1,592	1,310
3-Basement	1,249	116.0	8,345	853	2,446	250
Sub-Total	4,256	395.4	35,091	21,091	10,284	6,181
Ventilation Load	–	–	6,885	891	2,018	261
Latent cooling	–	–	–	6,595	–	1,933
TOTALS	**4,256**	**395.4**	**41,976**	**28,577**	**12,302**	**8,375**

2.3 Divide the house floor plan into HVAC zones

Using the builder's input from *"Decision #2"* of the **Zoning Checklist**, the mechanical designer should divide the house into individual heating and cooling zones. In this example the builder chose:

OPTION A: Assign one zone per floor including basement

To implement this option, the rooms on each level were grouped into three zones labeled "*basement zone*", "*main floor zone*" and "*second floor zone*" in the HVAC design software using the zoning tree window as shown in the top-left of Figure B-21.

This results in each floor being assigned to a separate zone as confirmed by the different coloured floor plans displayed in the HVAC design software shown in Figure B-8. It should be noted that the conditioned cavity space above the garage ceiling is part of the second-floor zone.

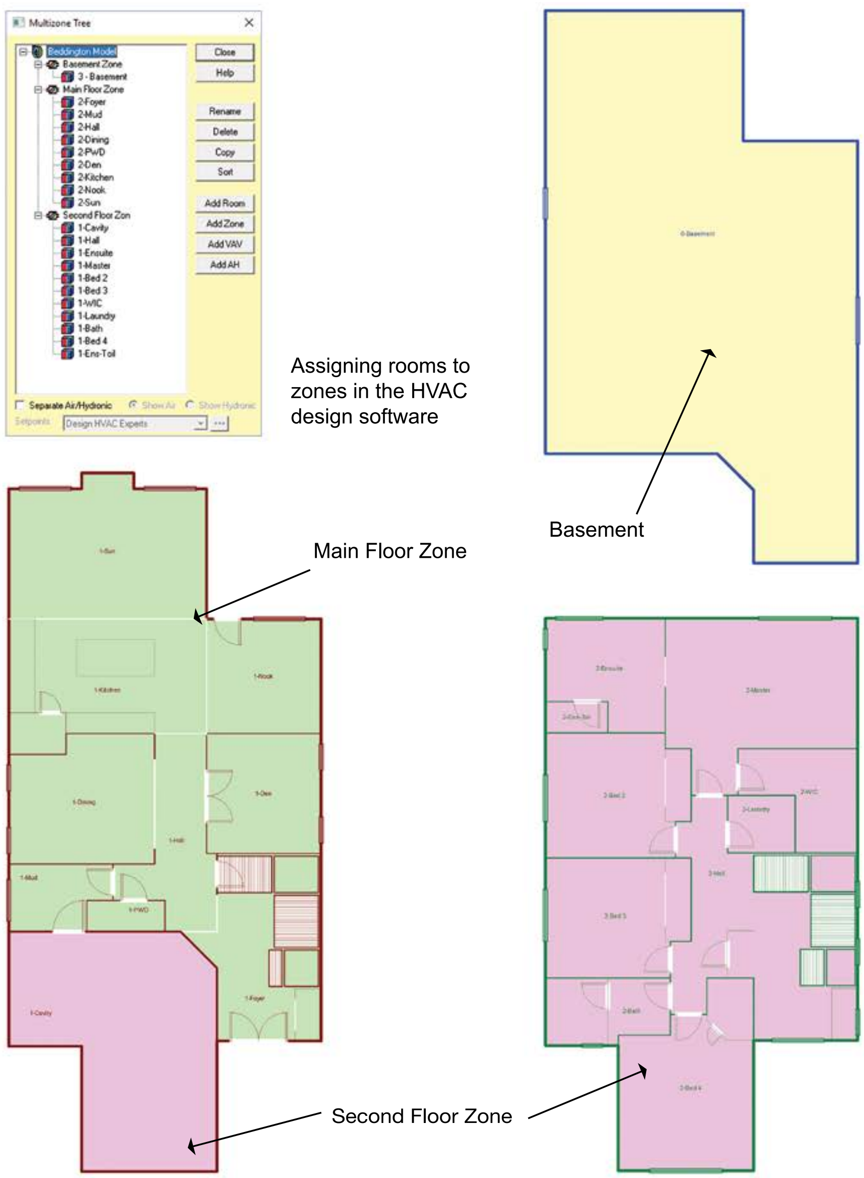


Figure B-21: Example of Floor-by-Floor Zoning using a Software Design Tool

2.4 Determine Zone Heat Loss and Gain Values

Now that the rooms have been grouped into zones, the mechanical designer should calculate the zone-by-zone heat loss and gain values. A summary of the zone heating and cooling load values are provided in Table B-20 for the example design.

Table B-20: Summary of Zone Heating and Cooling Loads for the Example Design

ZONE NAME	Area (ft^2)	Area (m^2)	Heating Load (Btuh)	Cooling Load (Btuh)	Heating Load (Watts)	Cooling Load (Watts)
Second Floor Zone	1,751	162.7	14,235	10,271	4,172	3,010
Main Floor Zone	1,256	116.7	12,511	9,967	3,666	2,921
Basement Zone	1,249	116.0	8,345	853	2,446	250
Sub-Total	4,256	395.4	35,091	21,091	10,284	6,181
Ventilation Load			6,885	891	2,018	261
Latent cooling				6,595		1,933
TOTALS	**4,256**	**395.4**	**41,976**	**28,577**	**12,302**	**8,375**

Testing for Equal Sized Zones

The appropriateness of the zoning plan can be evaluated using the “equal sized” criteria shown in Table B-21 for houses with 2, 3 or 4 HVAC zones. Since this design example has three HVAC zones, the target range for individual zone heating load fractions is 23% to 43%. If the ventilation load is calculated as a separate heat loss and not within each room load then divide the zone heating load by the total heat loss prior to adding in the ventilation load.

For example, the second floor zone heating load fraction is: **14,235 / 35,091 = 41%**

Table B-21: Testing the Zoning Plan for “Equal-Sized Zones

No. of HVAC Zones (N)	Target Range for “Equal Sized” Individual Zone Heating Loads	Result
2	40% to 60% of total heating load	n/a
3	**23% to 43% of total heating load**	**Second floor zone: 41%** **Main floor zone: 36%** **Basement zone: 24%**
4	15% to 35% of total heating load	n/a

In this example the individual zone heating load fractions range from 24% to 41% and are all within the target range for a three-zone system. In some designs, individual zone values will sometimes fall slightly outside these guideline values, which is acceptable as long as the zone trunk sizes pass the “excessive air velocity / noise level” criteria discussed in Step 5.

Upon completing Step 2, you will have:

- ☐ Confirmed or adjusted the builder’s initially defined zoning approach.
- ☐ Calculated the design heating and cooling loads for the individual zones and the overall house to be used in the equipment selection and sizing in STEP 3.

STEP 3: DEFINE HEATING & COOLING EQUIPMENT REQUIREMENTS

3.1 Choose the air-distribution strategy

The notes under the "*Other Instructions*" section of the **Zoning Checklist** indicate a preference for "high-wall central supply registers", which is:

OPTION B: Central Supply Duct Layout

In "*Decision #7*" of the **Zoning Checklist** the builder's preference of duct system velocity / static pressure characteristic was identified as:

OPTION A: Low Velocity (low static pressure)

Checking the **Decision Matrix** (i.e., Table 3-1 in ***Zoning Duct Design Guide***) this set of options falls within the scope of the ***Zoning Duct Design Guide***, with some restrictions on the type of supply grilles / diffusers that can be used.

3.2 Choose the type of zoned installation

Of the three options available within "*Decision #3*" of the **Zoning Checklist**, the builder selected:

OPTION A: Factory-integrated Zoned HVAC Equipment

To fulfil this requirement, the designer selected a factory-integrated zoned air handler unit (AHU) similar to the unit shown in Figure B-9. This unit is heated by a tankless water heater and cooled by a single-stage air-conditioner as requested by the builder under the "*Other Instructions*" section of the **Zoning Checklist**.

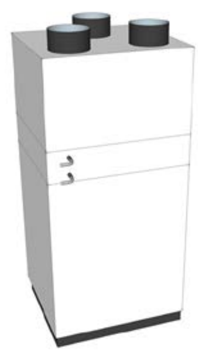


Figure B-22: Example of a Factory-integrated Zoned Air Handler Unit (AHU)

A summary of the heating and cooling equipment specifications are provided in Section 3.5.

3.3 Choose approach to meeting a demand from a single zone

Of the three options available within "*Decision #4*" of the **Zoning Checklist**, the builder selected:

OPTION A: System fully modulates or stages airflow

In this design example, the equipment selected by the designer in Step 3.2 operates as:

OPTION B: System uses directs airflow to non-calling zones

Small changes to the equipment specification can be expected as the zoned HVAC design is completed. We recommend designers consult with their builders to ensure the final design still meets expectations.

3.4 Choose changeover approach between heating and cooling

The changeover approach selected by the builder in "*Decision #5*" of the **Zoning Checklist** was:

OPTION A: Controller enables occupant to seasonally switch-over from heating to cooling

Factory-integrated zoned equipment, such as the zoned air-handler unit chosen in Step 3.2, have zoning controllers that are "hard-wired" to use the Option A changeover approach. No equipment setup is required to select this changeover option.

3.5 Specify the equipment output capacity

As per CSA F280-12 (paragraph 5.3.1) the total capacity of the all heating systems installed in a building shall be not less than 100% of the total building heat loss. This same standard applies to zoned systems. As calculated in Step 2.2, the total heating load is 41,976 Btu/h (12.3 kW). The heating equipment selected has a rated output of **47,700 Btu/h (14.0 kW)**, which is 114% of the calculated heating load.

The recommended guideline for **zoned cooling appliances** is to size equipment output between 80% and 100% of the calculated total equipment cooling load[12] , and to not oversize the cooling equipment. As calculated in Step 2.2, the total cooling load is 28,580 Btu/h (8.38 kW). The cooling equipment selected has a rated output of **24,200 Btu/h** (7.09 kW), which is 85% of the calculated cooling load.

12 The sizing guideline for **zoned air-conditioner capacity** is a modification of the HRAI sizing guideline for **non-zoned systems**, which recommends air-conditioner condenser capacity of 80% to 125% of total cooling load. See the ***Zoning Duct Design Guide*** document for additional details.

A complete summary of the heating and cooling equipment selected for this example zoned HVAC design is shown in Table B-22.

Table B-22: Equipment Selection Summary

Heating:			Cooling:		
Make: Example Zoned Air Handler			Make: TBD		
Trade: Zoned Air Handler			Trade: TBD		
Model: 3gpm@140F; 14 L/m@60C			Condenser: 2.0 Tons Provision		
Ref: DC Blower			Coil Static Loss: 0.25 in WG 62.5 Pa		
Efficiency	94.0 AFUE	94.0 AFUE	Efficiency	12.0 EER, 14 SEER	
Heating input	50,700 Btuh	14.9 kW	Sensible cooling	18,634 Btuh	5.46 kW
Heating output	47,700 Btuh	14.0 kW	Latent cooling	5,566 Btuh	1.63 kW
Temperature rise	55 °F	31 °C	Total cooling	24,200 Btuh	7.09 kW
Actual air flow	800 cfm	378 L/s	Actual air flow	800 cfm	378 L/s
Air flow factor	0.023 cfm/Btuh	0.037 L/s-W	Air flow factor	0.036 cfm/Btuh	0.061 L/s-W
Static pressure	0.5 in WG	125 Pa	Static pressure	0.5 in WG	125 Pa
			Load sensible heat ratio	0.77	0.77

Upon completing Step 3, you will have:

- ☐ Chosen the Air Distribution Strategy to be implemented in STEP 5;
- ☐ Confirmed or adjusted the builder's selection of operating external static pressure (ESP) for the HVAC system;
- ☐ Confirmed or adjusted the builder's selection of zoned equipment type to be installed;
- ☐ Narrowed the possible suppliers of the zoned equipment based on zoning control features; and,
- ☐ Calculated the required thermal output values for the zoned heating and cooling equipment.

STEP 4: SPECIFY THE RETURN-AIR DUCTING REQUIREMENTS

4.1 Specify return-air duct installation method

The notes under the “*Other Instructions*” section of the **Zoning Checklist** indicate a request for “hard-ducted returns”, which is:

OPTION B: Hard-ducted Return Installation

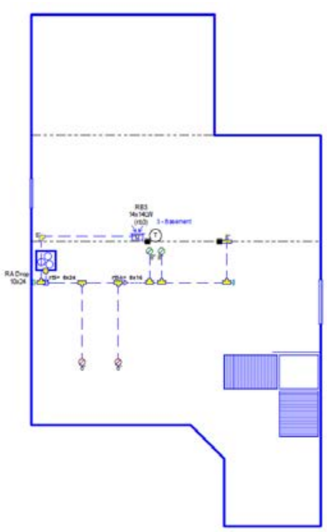
4.2 Specify location of return-air outlets

The notes under the “*Other Instructions*” section of the **Zoning Checklist** indicate a request for “simplified returns”, which is:

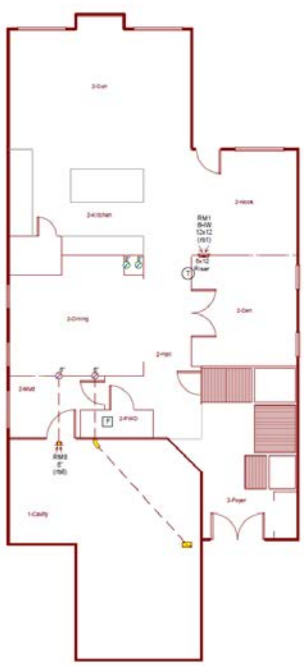
OPTION B: Simplified Return Inlet Layout

4.3 Layout return-air ducts

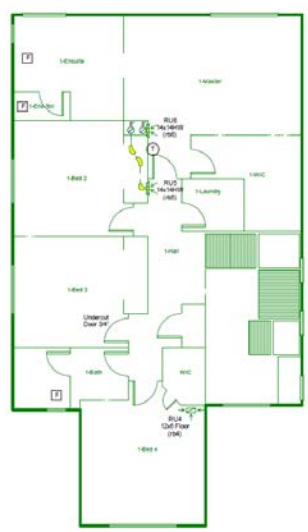
The resulting return-air duct system for the example house model is shown in Figure B-23.



Basement Return Layout



Main Floor Return Layout



Second Floor Return Layout

Figure B-23: Return duct layout for the Example Duct Design

4.4 Specify return-air duct sizing

Tables B-23 and B-24 summarize the duct sizes and relative performance of each individual return branch.

Table B-23: Return Branch (RB) Design Details (Imperial units)

Branch Name	Grill Size (in)	Heating (cfm)	Cooling (cfm)	Equiv-alent Length (ft)	Design Friction	Velocity (fpm)	Diameter (in)	Height x Width (in)	Duct Material	Connected to
RB1	12x8	140	196	274.3	0.054	561	8	-	ShMt	RT5A
RB3	14x7	218	84	181.5	0.082	625	8	-	ShMt	RT4
RB4	12x4	60	94	302.2	0.049	477	6	-	ShMt	RT5
RB5	14x7	171	201	305.4	0.049	577	8	-	ShMt	RT5A
RB6	14x7	152	201	315.0	0.047	576	8	-	ShMt	RT5A
RB8	n/a	58	24	234.3	0.064	295	6	-	ShMt	RT5

Table B-24: Return Branch (RB) Design Details (metric units)

Branch Name	Grill Size (mm)	Heat-ing (L/s)	Cooling (L/s)	Equiv-alent Length (m)	Design Friction	Velocity (m/s)	Diameter (mm)	Height x Width (mm)	Duct Material	Con-nected to
RB1	305x192	66	92	83.59	0.444	2.85	203	-	ShMt	RT5A
RB3	356x183	103	39	55.32	0.671	3.18	203	-	ShMt	RT4
RB4	305x92	28	44	92.10	0.403	2.42	152	-	ShMt	RT5
RB5	356x169	81	95	93.07	0.399	2.93	203	-	ShMt	RT5A
RB6	356x169	72	95	96.01	0.387	2.93	203	-	ShMt	RT5A
RB8	n/a	27	12	71.40	0.520	1.5	152	-	ShMt	RT5

Note that all return branches RB1, RB3, RB4, RB5, RB6 and RB8 are installed as hard-ducted (ShMt) returns.

The return inlet locations are shown in Figure B-23 and are assigned to the zones as follows.

- RB4, RB5, RB6 and RB8 return air from the second floor zone (zone 1).
- RB1 returns air from the main floor zone (zone 2).
- RB3 returns air from the basement zone (zone 3).

In spite of appearing on the main-floor return layout in Figure B-23, RB8 returns air from the cavity space above the garage ceiling which was assigned to the second-floor zone in Step 2.3.

Tables B-25 and B-26 summarize the duct sizes and relative performance of the corresponding return trunks RT1, RT4, RT5 and RT5A which are installed using rectangular sheet metal (ShMt) ducts.

Table B-25: Return Trunk (RT) Design Details (imperial units)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction	Velocity (fpm)	Diameter (in)	Height x Width (in)	Duct Material	Connected to
RT1	Peak AVF	800	800	0.047	480	–	10 x 24	ShMt	equipment
RT4	Peak AVF	218	84	0.082	164	–	8 x 24	ShMt	RT1
RT5	Peak AVF	582	716	0.047	537	–	8 x 24	ShMt	RT1
RT5A	Peak AVF	464	598	0.047	673	–	8 x 16	ShMt	RT5

Table B-26: Return Trunk (RT) Design Details (metric units)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction	Velocity (m/s)	Diameter (mm)	Height x Width (mm)	Duct Material	Connected to
RT1	Peak AVF	378	378	0.387	2.44	–	254 x 610	ShMt	equipment
RT4	Peak AVF	103	39	0.671	0.83	–	203 x 610	ShMt	RT1
RT5	Peak AVF	275	338	0.387	2.73	–	203 x 610	ShMt	RT1
RT5A	Peak AVF	218	282	0.387	3.42	–	203 x 406	ShMt	RT5

The return air velocities are well within the HRAI maximum velocity guidelines of 650 fpm (3.30 m/s) for return branches and 700 fpm (3.56 m/s) for return trunks.

Upon completing STEP 4, you will have:

- ☐ Specified the location, size and placement of return-air inlets in the home,
- ☐ Defined the return duct routing on the house plans,
- ☐ Specified the size of the return branches and the return trunk ducting,
- ☐ Specified the type of return branch and return trunk ducting and installation method.

STEP 5: SPECIFY THE SUPPLY-AIR DUCTING REQUIREMENTS

5.1 Specify location of supply-air outlets

Following from the Air Distribution Strategy decision made in STEP 3.1, the supply system was designed as a low-velocity, low-pressure duct system using:

OPTION B – Central Supply Duct Layout

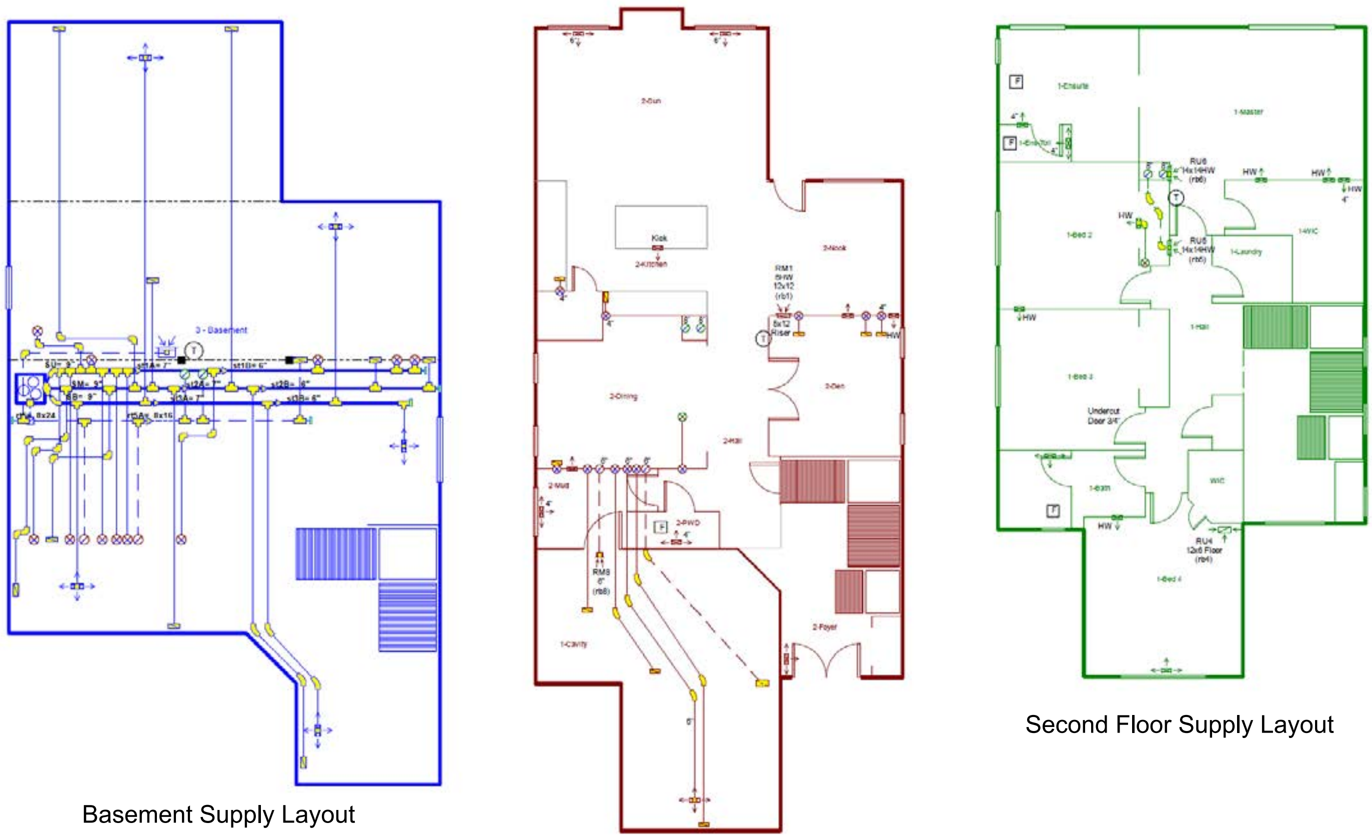
This option emphasizes the use of interior high wall outlets, supplemented by other supply outlet locations as necessary in order to satisfy the design requirements of the various rooms.

5.2 Specify type of ducts used for supply branches

Following the directions from the ***Zoning Duct Design Guide***, the supply branches were designed using rigid, round ducting.

5.3 Layout supply-air ducts

The resulting supply-air duct system shown in Figure B-24 is superimposed on the floor plans for the example house model as solid lines. The return-air duct system is also shown as dashed lines.



Basement Supply Layout

Main Floor Supply Layout

Second Floor Supply Layout

Figure B-24: Supply Duct Layout for the Example Zoned Duct Design

5.4 Specify type of ducts used for the zone supply trunks

The mechanical designer gets to choose either "*Traditional Rectangular*" or "*Round or Oval*" supply trunks. In this example, the designer chose to use round supply trunks, which is:

OPTION B – Round or Oval Ductwork

5.5 Specify supply-air duct sizing

Supply Branch Sizing

When sizing the supply branches the designer should apply HRAI's branch sizing guidelines to ensure each branch is sized accordingly. This means each branch must be able to manage the higher of either heating or cooling airflow and the diameter be sized using either the HRAI or the manufacturer's sizing standards.

Tables B-27 (imperial units) and B-28 (metric units) summarize the duct sizes and relative performance of each individual supply branch. Each of the supply branches connects to one of the three zone supply trunks.

Table B-27: Supply Branch Duct Design Details (imperial units)

Branch Name	Design (Btuh)	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Diameter (in)	Actual Length (ft)	Fittings Equivalent Length (ft)	Total Equivalent Length (ft)	Connected to
1-Bath	c 829	20	31	0.053	5.0	34.8	155.0	189.8	ST1
1-Bed-2	c 1,060	33	40	0.047	5.0	52.6	160.0	212.6	ST1A
1-Bed-3	c 1,284	42	49	0.048	5.0	24.8	185.0	209.8	ST1
1-Bed-4	c 1,640	40	62	0.051	5.0	58.0	140.0	198.0	ST1
1-Bed-4-A	c 1,640	40	62	0.045	5.0	43.1	135.0	178.1	ST1
1-Cavity	h 2,349	54	12	0.053	6.0	55.3	135.0	190.3	ST1
1-Ens-Toil	c 281	3	11	0.067	4.0	15.3	135.0	150.3	ST1
1-Ensuite	c 591	22	22	0.055	4.0	19.1	165.0	184.1	ST1
1-Master	c 933	26	35	0.062	5.0	36.6	125.0	161.6	ST1B
1-Master-A	c 933	26	35	0.061	5.0	31.1	135.0	166.1	ST1B
1-WIC	c 752	18	29	0.066	4.0	37.8	115.0	152.8	ST1B
2-Den	c 862	29	33	0.089	5.0	28.8	85.0	113.8	ST1B
2-Dining	c 1,351	28	51	0.070	5.0	19.0	125.0	144.0	ST2
2-Foyer-A	h 1,710	39	17	0.071	5.0	41.9	100.0	141.9	ST2A
2-Kitchen-A	c 308	10	12	0.101	5.0	15.0	85.0	100.0	ST2
2-Mud	c 444	12	17	0.058	4.0	19.0	155.0	174.0	ST2
2-Nook	c 1,758	39	67	0.084	5.0	25.0	95.0	120.0	ST2B
2-PWD	c 317	4	12	0.100	4.0	25.5	75.0	100.5	ST2
2-Sun	h 2,235	62	85	0.066	6.0	36.5	115.0	151.5	ST2
2-Sun-A	h 2,235	62	85	0.079	6.0	38.0	90.0	128.0	ST2A
3-Basement	h 1,669	38	6	0.073	5.0	33.0	105.0	138.0	ST3B
3-Basement-A	h 1,669	38	6	0.082	5.0	28.5	95.0	123.5	ST3B
3-Basement-B	h 1,669	38	6	0.086	5.0	31.6	85.0	116.6	ST3
3-Basement-C	h 1,669	38	6	0.067	5.0	40.1	110.0	150.1	ST3A
3-Basement-D	h 1,669	38	6	0.080	5.0	15.5	110.0	125.5	ST3

Table B-28: Supply Branch Duct Design Details (metric units)

Branch Name	Design (W)		Heating (L/s)	Cooling (L/s)	(L/s) Design Friction (ratio)	Diameter (mm)	Actual Length (m)	Fittings Equiv-alent Length (m)	Total Equiv-alent Length (m)	Connected to
1-Bath	c	243	10	15	0.433	127	10.62	47.24	57.86	ST1
1-Bed-2	c	311	16	19	0.387	127	16.03	48.77	64.80	ST1A
1-Bed-3	c	376	20	23	0.392	127	7.57	56.39	63.96	ST1
1-Bed-4	c	481	19	29	0.415	127	17.68	42.67	60.35	ST1
1-Bed-4-A	c	481	19	29	0.462	127	13.14	41.15	54.29	ST1
1-Cavity	h	688	25	6	0.432	152	16.87	41.15	58.02	ST1
1-Ens-Toil	c	82	2	5	0.547	102	4.68	41.15	45.83	ST1
1-Ensuite	c	173	10	11	0.447	102	5.82	50.29	56.11	ST1
1-Master	c	273	12	17	0.509	127	11.15	38.10	49.25	ST1B
1-Master-A	c	273	12	17	0.495	127	9.48	41.15	50.63	ST1B
1-WIC	c	220	9	13	0.538	102	11.54	35.05	46.59	ST1B
2-Den	c	253	14	15	0.723	127	8.76	25.91	34.67	ST1B
2-Dining	c	396	13	24	0.571	127	5.79	38.10	43.89	ST2
2-Foyer-A	h	501	18	8	0.579	127	12.79	30.48	43.27	ST2A
2-Kitchen-A	c	90	5	6	0.822	127	4.57	25.91	30.48	ST2
2-Mud	c	130	6	8	0.473	102	5.79	47.24	53.03	ST2
2-Nook	c	515	18	31	0.685	127	7.62	28.96	36.58	ST2B
2-PWD	c	93	2	6	0.818	102	7.77	22.86	30.63	ST2
2-Sun	h	655	29	40	0.543	152	11.13	35.05	46.18	ST2
2-Sun-A	h	655	29	40	0.643	152	11.58	27.43	39.01	ST2A
3-Basement	h	489	18	3	0.596	127	10.06	32.00	42.06	ST3B
3-Basement-A	h	489	18	3	0.666	127	8.69	28.96	37.65	ST3B
3-Basement-B	h	489	18	3	0.706	127	9.60	25.91	35.51	ST3
3-Basement-C	h	489	18	3	0.548	127	12.23	33.53	45.76	ST3A
3-Basement-D	h	489	18	3	0.655	127	4.72	33.53	38.25	ST3

Zone Supply Trunk Sizing

Sizing the zone supply trunks is a two part process involving:

1. Preliminary zone trunk sizing based on design airflow requirements,
2. Checking zone trunks for excessive air velocity /noise during single-zone operation.

Preliminary Zone Supply Trunk Sizing based on design airflow requirements

The designer should determine the preliminary sizes of the supply trunks by applying HRAI's sizing guidelines. This means each trunk must be able to manage the higher of either heating or cooling airflow and be sized using either the HRAI or the manufacturer's sizing standards.

Tables B-29 (imperial units) and B-30 (metric units) summarize the preliminary duct sizes and relative performance of each of the three zone supply trunks.

Table B-29: Preliminary Supply Trunk (ST) Design Details (imperial units)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Velocity (fpm)	Diameter (in)	Height x Width (in)	Duct Material	Connected to
ST1	Peak AVF	325	390	0.047	882	9	–	ShMt	–
ST1A	Peak AVF	104	139	0.047	522	7	–	ShMt	ST1
ST1B	Peak AVF	70	99	0.061	506	6	–	ShMt	ST1A
ST2	Peak AVF	285	378	0.058	856	9	–	ShMt	–
ST2A	Peak AVF	169	201	0.071	754	7	–	ShMt	ST2
ST2B	Peak AVF	68	99	0.084	506	6	–	ShMt	ST2A
ST3	Peak AVF	190	32	0.067	545	8	–	ShMt	–
ST3A	Peak AVF	114	19	0.067	427	7	–	ShMt	ST3
ST3B	Peak AVF	76	13	0.073	388	6	–	ShMt	ST3A
Total	–	800	800	–	–	–	–	–	–

Table B-30: Preliminary Supply Trunk (ST) Design Details (metric units)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Velocity (m/s)	Diameter (mm)	Height x Width (mm)	Duct Material	Connected to
ST1	Peak AVF	153	184	0.387	4.48	229	–	ShMt	–
ST1A	Peak AVF	49	66	0.387	2.65	178	–	ShMt	ST1
ST1B	Peak AVF	33	47	0.495	2.57	152	–	ShMt	ST1A
ST2	Peak AVF	135	178	0.473	4.35	229	–	ShMt	–
ST2A	Peak AVF	80	95	0.579	3.83	178	–	ShMt	ST2
ST2B	Peak AVF	32	47	0.685	2.57	152	–	ShMt	ST2A
ST3	Peak AVF	90	15	0.548	2.77	203	–	ShMt	–
ST3A	Peak AVF	54	9	0.548	2.17	178	–	ShMt	ST3
ST3B	Peak AVF	36	6	0.596	1.97	152	–	ShMt	ST3A
Total	–	378	378	–	–	–	–	–	–

In this design example, each zone trunk has three sections of different diameters with reducers joining the sections together. The zone trunks are arranged as follows:

- ST1, ST1A and ST1B supply the second floor zone,
- ST2, ST2A and ST2B supply the main floor zone, and
- ST3, ST3A and ST3B supply the basement zone.

All sections of the zone trunks have supply velocities that are within the HRAI recommendation for a maximum velocity of 900 fpm (4.57 m/s) when all zones are open and operating at design conditions.

Checking zone trunks for excessive air velocity / noise during single-zone operation

The mechanical designer should calculate and check the air velocity in each of the zone supply trunks at a “noise test” condition which simulates single-zone operation.

- Any zone trunk moving 50% or more of the total system design airflow (e.g., ≥ 400 cfm for an 800 cfm system) should be “noise tested” at the design airflow for that trunk.
- Any zone trunk moving less than 50% of the total system design airflow (e.g., < 400 cfm for an 800 cfm system) should be “noise tested” as if the supply trunk is moving 50% of the system airflow at the plenum connection, before any transition, taper or supply branch takeoff.
- If the zone supply trunk includes transitions or tapers to smaller downstream sections, the “noise test” airflow for the downstream sections should be adjusted by the “% trunk airflow fraction” calculated at design airflow conditions for that trunk.

Noise Test Conditions

The design airflows for the three supply trunks, ST1, ST2 and ST3 are 390 cfm, 378 cfm and 190 cfm (184 L/s, 178 L/s and 90 L/s) respectively. Since these values are below 50% of the total system design airflow of 800 cfm (378 L/s), the “noise test” for each of the supply trunks will be evaluated at 50% of the total system design airflow, or 400 cfm (378 L/s) entering each supply trunk.

Noise Test Airflows after a Trunk Taper: The airflows entering each downstream section of a zone trunk immediately after a taper (e.g. ST1A) will be lower than the “noise test” airflow entering the initial section of the zone trunk (e.g., ST1) as a result of airflows in upstream supply branches. The downstream “noise test” airflows are calculated using the “trunk section airflow ratio” or %Trunk airflow for each of the downstream sections.

%Trunk airflow in Section ST1A	**= design airflow in ST1A / design airflow in ST1**
	= 139 cfm / 390 cfm = 35.6%

The “noise test” airflow in trunk section ST1A is calculated as follows:

Noise test airflow in Section st1A	**= Noise Test airflow entering the ST1 x %Trunk airflow in ST1A**
	= 400 cfm x 35.6% = 143 cfm

“Noise test” airflow values for the other supply trunks are calculated in a similar way and are shown in the second column from the right in Table B-31 (imperial units) and in Table B-32 (metric units).

Noise Test Air Velocities: The resulting "noise test" air velocity can be calculated in each trunk section using the following formula:

In imperial units, the "noise test" air velocity (fpm) equals "noise test" airflow (cfm) times 144 divided by the "trunk area" (sq-in), or:

fpm = cfm x 144 / sq-in

In metric units, the "noise test" air velocity (m/s) equals "noise test" airflow (L/s) times 1000 divided by the "trunk area" (mm^2), or:

m/s = L/s x 1000 / mm^2

Noise Test Calculations

Using the preliminary design data from Tables B-29 (imperial units) and B-30 (metric units), and the formulas described above, the sizing of the supply trunk sections were evaluated at "noise test" conditions which simulate single-zone operation, with the velocity results shown in the right-hand columns of Table B-31 (imperial units) and Table B-32 (metric units).

Table B-31: Testing Supply Trunks (ST) for **"noise test" levels** (imperial units)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Velocity (fpm)	Diameter (in)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (cfm)	Noise Test Velocity (fpm)
ST1	Peak AVF	325	390	0.047	882	9	–	100%	400	900
ST1A	Peak AVF	104	139	0.047	522	7	ST1	36%	143	533
ST1B	Peak AVF	70	99	0.061	506	6	ST1A	25%	36	PASS 184
ST2	Peak AVF	285	378	0.058	856	9	–	100%	400	900
ST2A	Peak AVF	169	201	0.071	754	7	ST2	53%	213	796
ST2B	Peak AVF	68	99	0.084	506	6	ST2A	26%	56	283
ST3	Peak AVF	190	32	0.067	545	8	–	100%	400	1145 FAIL
ST3A	Peak AVF	114	19	0.067	427	7	ST3	60%	240	898
ST3B	Peak AVF	76	13	0.073	388	6	ST3A	40%	160	PASS 814
Total	**–**	**800**	**800**							

Table B-32: Testing Supply Trunks (ST) for **"noise test" levels** (metric units)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Velocity (m/s)	Diameter (mm)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (L/s)	Noise Test Velocity (m/s)
ST1	Peak AVF	153	184	0.387	4.48	229	–	100%	189	4.57
ST1A	Peak AVF	49	66	0.387	2.65	178	ST1	36%	67	2.71
ST1B	Peak AVF	33	47	0.495	2.57	152	ST1A	25%	17	PASS 0.94
ST2	Peak AVF	135	178	0.473	4.35	229	–	100%	189	4.57
ST2A	Peak AVF	80	95	0.579	3.83	178	ST2	53%	100	4.04
ST2B	Peak AVF	32	47	0.685	2.57	152	ST2A	26%	26	1.44
ST3	Peak AVF	90	15	0.548	2.77	203	–	100%	189	5.82 FAIL
ST3A	Peak AVF	54	9	0.548	2.17	178	ST3	60%	113	4.56 PASS
ST3B	Peak AVF	36	6	0.596	1.97	152	ST3A	40%	76	4.14
Total	**–**	**378**	**378**							

Noise-Test Results:

- **All sections of zone trunks 1 and 2 passed** the excessive air velocity/noise test with calculated velocities less than or equal to 900 fpm (4.57 m/s) at the "noise-test" conditions.
- **Section ST3 of zone trunk 3 failed** the excessive air velocity/noise test with calculated air velocities of 1,145 fpm (5.82 m/s) respectively at the "noise-test" conditions.
- **Sections ST3A and ST3B of zone trunk 3 passed** the excessive air velocity/noise test with calculated velocities less than or equal to 900 fpm (4.57 m/s) at the "noise-test" conditions.

Final Zone Supply Trunk Design

To remedy the high velocity in section ST3 of supply trunk 3 during single-zone operation, section ST3 should be increased in size to a 9-in (229 mm) duct.

The final supply trunk design and noise-test velocities for the example 3-zone HVAC system are summarized in Tables B-33 and B-34, in which all "noise-test" velocities are less than or equal to 900 fpm (4.57 m/s).

Table B-33: Final Supply Trunk Details, with Increased Duct Size to Accommodate Single-Zone Operation (imperial)

Trunk Name	Trunk Type	Heating (cfm)	Cooling (cfm)	Design Friction (ratio)	Velocity (fpm)	Diameter (in)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (cfm)	Noise Test Velocity (fpm)
ST1	Peak AVF	325	390	0.047	882	9	–	100%	400	900
ST1A	Peak AVF	104	139	0.047	522	7	ST1	36%	143	533
ST1B	Peak AVF	70	99	0.061	506	6	ST1A	25%	36	184
ST2	Peak AVF	285	378	0.058	856	9	–	100%	400	900
ST2A	Peak AVF	169	201	0.071	754	7	ST2	53%	213	796
ST2B	Peak AVF	68	99	0.084	506	6	ST2A	26%	56	283
ST3	Peak AVF	190	32	0.067	545	8	–	100%	400	1145
ST3A	Peak AVF	114	19	0.067	427	7	ST3	60%	240	898
ST3B	Peak AVF	76	13	0.073	388	6	ST3A	40%	160	814
Total	**–**	**800**	**800**							

PASS

Table B-34: Final Supply Trunk Details, with Increased Duct Size to Accommodate Single-Zone Operation (metric)

Trunk Name	Trunk Type	Heating (L/s)	Cooling (L/s)	Design Friction (ratio)	Velocity (m/s)	Diameter (mm)	Connected to	Trunk Section Airflow Ratio	Noise Test Airflow (L/s)	Noise Test Velocity (m/s)
ST1	Peak AVF	153	184	0.387	4.48	229	–	100%	189	4.57
ST1A	Peak AVF	49	66	0.387	2.65	178	ST1	36%	67	2.71
ST1B	Peak AVF	33	47	0.495	2.57	152	ST1A	25%	17	0.94
ST2	Peak AVF	135	178	0.473	4.35	229	–	100%	189	4.57
ST2A	Peak AVF	80	95	0.579	3.83	178	ST2	53%	100	4.04
ST2B	Peak AVF	32	47	0.685	2.57	152	ST2A	26%	26	1.44
ST3	Peak AVF	90	15	0.548	2.77	203	–	100%	189	5.82
ST3A	Peak AVF	54	9	0.548	2.17	178	ST3	60%	113	4.56
ST3B	Peak AVF	36	6	0.596	1.97	152	ST3A	40%	76	4.14
Total	**–**	**378**	**378**							

PASS

In the final design, the three zone supply trunks start at the equipment as 9-in (229-mm) diameter ducts, reducing to 7-in (178-mm) diameter ducts for the middle sections and to 6-in (152-mm) diameter ducts for the final sections of each trunk.

5.6 Specify supply-air duct sealing requirements

The notes under the *"Other Instructions*" section of the **Zoning Checklist** indicate a request for "upgrade duct sealing to Class A", which is:

OPTION B: Upgrade sealing practices to SMACNA "Class A" throughout

5.7 Specify supply-air trunk labelling requirements

Zone trunk identification labels for this three-zone example design are:

- "*Second Floor*" for ST1.
- "*Main Floor*" for ST2 and
- "*Basement*" for ST3.

Upon completing STEP 5, you will have:

- ☐ Specified the location, size and type of supply-air outlets in each room.
- ☐ Defined supply duct routing to optimize flow and equivalent lengths.
- ☐ Specified the type of ducting used for supply branches and zone supply trunks.
- ☐ Completed preliminary duct sizing for supply branches and zone supply trunks.
- ☐ Checked zone supply ducting for potential excessive velocity/noise levels during single-zone operation, and adjusted duct sizes as required.
- ☐ Defined the final duct sizes for zone supply trunks to mitigate excessive air velocity/noise during single-zone operation.
- ☐ Specified the supply-duct sealing requirements.
- ☐ Specified the zone supply-trunk labelling requirements.

STEP 6: SPECIFY THERMOSTAT REQUIREMENTS

6.1 Specify thermostat locations

The mechanical designer should specify the location of each zone thermostat on the house floor plans. The best practice applications for zone thermostat locations are described in section 6.1, and are illustrated in Figure B-25 for the example house.

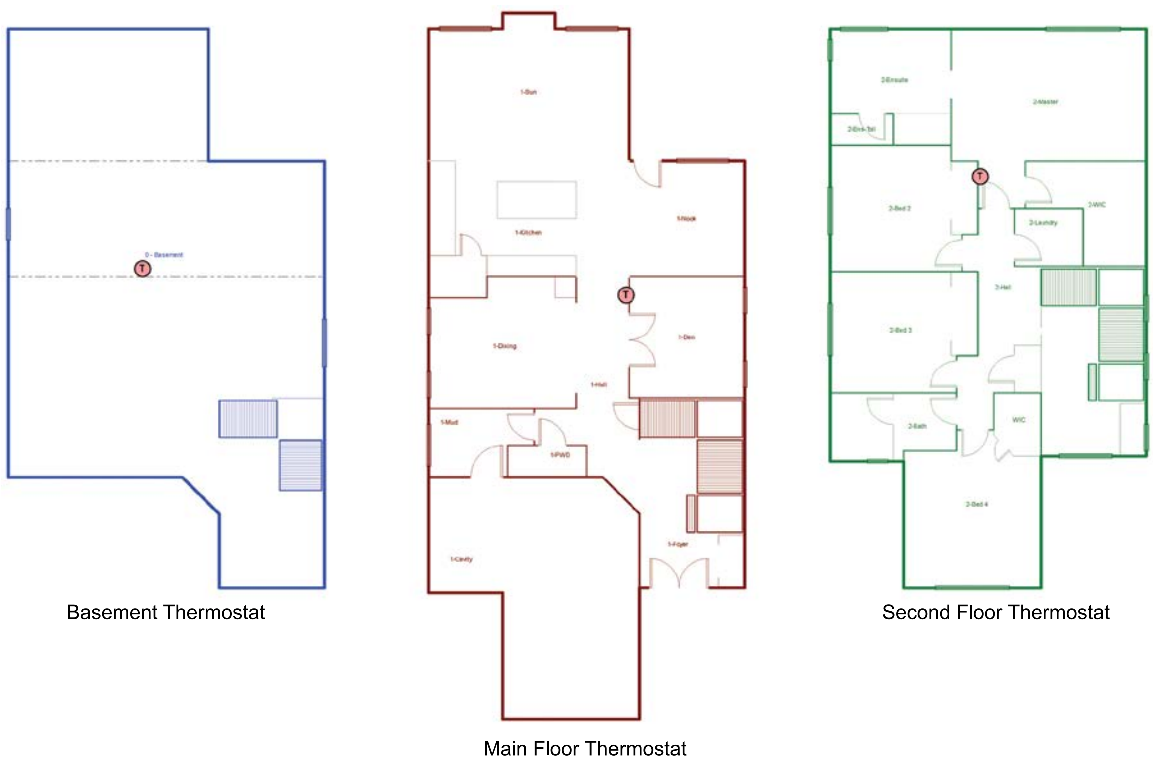


Figure B-25: Zone Thermostat Locations in the Example Three-Zone HVAC Design

6.2 Specify thermostat wiring and labelling requirements

The mechanical designer should specify thermostat wiring as defined in Section 6.2 and require wiring labels on both ends of each set of wires with a unique zone identifier consistent with the labels used on the zone supply trunks. In this three-zone system, zoned by floor, the labels would be:

- "*Basement*",
- "*Main Floor*" and
- "*Second Floor*"

6.3 Specify thermostat type and installation requirements

As selected by the builder within the **Zoning Checklist**:

Option A: Programmable Thermostats

Upon completing STEP 6, you will have:

- ☐ Defined and marked the thermostat locations on the house plans for each zone in the home.
- ☐ Specified the type of wiring and the identification labels to be used on each set of thermostat wires, and noted these installation requirements on the ducting plans for the home.
- ☐ Confirmed the number and type of thermostats to be installed in the home, and noted these installation requirements on the ducting plans for the home.

STEP 7: PREPARE INSTALLATION AND COMMISSIONING NOTES FOR THE HVAC INSTALLER AND TECHNICIAN

NOTE: In today's world of rapidly changing technology it is challenging to provide information that applies to all types of zoned HVAC equipment and to all installations.

- The following installation and commissioning notes are provided as a broad-based guide only.
- In all cases, the HVAC equipment manufacturers' installation and commissioning guidelines should be strictly adhered to.

Possible options for installation and commissioning notes are described in STEP 7 of the ***Zoning Duct Design Guide***.

The applicable installation and commissioning notes for this example duct design were copied and pasted onto a drawing template and attached as a DRAWING PAGE in the duct design as shown in Figure B-26.

Zoned Duct Design

INSTALLATION AND COMMISSIONING NOTES FOR THE HVAC INSTALLER AND TECHNICIAN

7.1 Return Duct Installation Method Notes

B. Use hard ducting for all return branches. Return branches are to be terminated in a rectangular return trunk that is connected to the equipment.

7.2 Supply Branch Ducts Installation Notes

A. All Installations: Supply branches should be installed using rigid round ducting, with suitable register boots, matched to the specified register diffuser grilles at each supply outlet location.

- Supply outlets located on interior walls require the use of long-throw diffusers with horizontal bars.
- Supply outlets located on ceilings can use either rectangular or round diffusers.

7.3 Zone Supply Trunks Installation Notes

B. Install zone supply trunks using rigid round ducting, with wye fitting or saddles used to connect to supply branches.

7.4 Supply Branch and Trunk Duct-Sealing Notes

B. Upgraded duct-sealing:

- Seal transverse joints, longitudinal seams and all applicable penetrations of the supply ducting (i.e. SMACNA "Class A" duct-sealing practices.

7.5 Supply Trunk Labelling Notes

A. Zone identification labels for a three-level house, zoned by floor:

- ST1 Label to read: "Second Floor"
- ST2 Label to read: "Main Floor"
- ST3 Label to read: "Basement"

7.6 Thermostat Wiring Labelling Notes

A. Zone identification labels for a three-level house, zoned by floor:

- Upper floor thermostat wiring labels to read: "Second Floor"
- Main floor thermostat wiring labels to read: "Main Floor"
- Basement thermostat wiring labels to read: "Basement"

7.7 Equipment Supply-Trunk Connection Notes

A. Factory Integrated Zoned Equipment:

- Connect each zone trunk to one of the zone supply outlets on the equipment.
- Any unused supply outlets on the equipment should be closed and sealed using a duct cap.

7.8 Equipment Commissioning and Airflow Setup Notes

A. All Installations: The HVAC technician is instructed to commission the HVAC equipment and setup the system airflows in accordance with the manufacturer's instructions for both heating and cooling operation.

7.9 Thermostat Connections and Zone Supply Air Delivery Notes

A. Zoned Equipment Installations:

- Install programmable thermostats in each zone at the specified locations.
- Check that a heating or cooling call from each individual zone thermostat results in the delivery of supply air to all supply outlets in the HVAC zone initiating the call.

Notes:

No. of Branches	S/A	R/A	Fans
3rd Floor:			
2nd Floor:			
1st Floor:			
Basement:			

Revision 1:	27-May-2015
Revision 2:	
Builder:	Cardel Homes
Contractor:	TBD
Project:	FOOTPRINT **Beddington Model**
Drawing Title:	Project Notes
Scale:	3/16" = 1'0"
Date:	6-May-2015
DWG NO.	**M0**

Figure B-26: Installation and Commissioning Notes for the Zoned HVAC Design

Upon completing STEP 7, you will have:

- ☐ Prepared return ducting installation notes.
- ☐ Prepared supply ducting installation notes.
- ☐ Prepared supply duct-sealing notes.
- ☐ Prepared zone supply trunk labelling notes.
- ☐ Prepared thermostat wiring labelling notes.
- ☐ Prepared supply-trunk to equipment connection notes.
- ☐ Prepared equipment commissioning and setup notes on:
  - Heating and cooling airflow setup,
  - Thermostat connection verification,
  - Zoning controller settings for heating / cooling mode changeover (if applicable).

APPENDIX C: REFERENCES

American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE). ASHRAE Handbook, 2007 – HVAC Applications. Section 47.8, Table 3 "*Maximum Recommended Duct Airflow Velocities Needed to Achieve Specified Acoustic Design Criteria*". 2007.

Canadian Standards Association (CSA). CSA F280-12: Determining the Required Capacity of Residential Space Heating and Cooling Appliances. 2012. Latest revision.

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