RESEARCH REPORT

The Impact of Requiring Residential HVAC System Design Submittal On System Performance

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FINAL REPORT

THE IMPACT OF REQUIRING RESIDENTIAL HVAC SYSTEM DESIGN SUBMITTAL ON SYSTEM PERFORMANCE

Prepared For

CANADA MORTGAGE AND HOUSING CORPORATION

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Executive Summary

In Canada, there are variations in the methods that authorities use to ensure that heating, ventilating and air conditioning systems are designed and installed properly in new residences. In particular, some authorities require submission of heat loss/gain calculations and duct designs prior to issuing building permits, while others do not. Also, some jurisdictions have more stringent inspection procedures in place than others.

While the National Building Code of Canada states that the capacity of residential heating appliances is to be determined in accordance with CAN/CSA-F280-M, many jurisdictions do not enforce this.

The purpose of this study is to compare the installed HVAC systems resulting from two different permit and inspection processes in two different cities in Canada.

City A: Requires the submission of heat loss calculations and duct sizes.

City B: Does not require the submission of heat loss calculations and duct sizes.

Significant deviations from code requirements were identified in each city. One could argue that the more rigorous inspection procedure in City B in part made up for the less stringent approval process. However, the study shows that City A does not necessarily enforce its own permit requirements and that the building inspection process in both cities missed flaws in some installations. The design requirements in City A appear to result in larger installed main ducts than in City B.

Despite the inability of builders, contractors and inspectors to ensure code compliance, homeowners had few complaints about the quality of their installations.

From the limited number of houses that were included in this study, it appears that there is little difference in the performance and perceived comfort levels of installed HVAC systems in the two cities with the current permit and inspection processes in place.

Résumé

Au Canada, les autorités vérifient de différentes façons la conception et l'installation tout indiquée des systèmes de chauffage, de ventilation et de conditionnement d'air dans les bâtiments neufs. En effet, certaines exigent de connaître les calculs de déperditions/gains de chaleur et les dimensions des conduits avant de délivrer le permis de construire, alors que d'autres ne le font pas. Certaines municipalités ont également recours à des méthodes d'inspection davantage rigoureuses que d'autres.

Le Code national du bâtiment du Canada précise que la capacité des appareils de chauffage résidentiels doit être déterminée conformément à la norme CAN/CSA-F280-M, mais bien des autorités n'appliquent pas cette disposition.

La présente étude vise à comparer les installations de chauffage, de ventilation et de conditionnement d'air, selon deux différents modes de délivrance de permis et d'inspection dans deux villes du Canada.

Ville A:	Exige les calculs des déperditions/gains de chaleur et les dimensions des conduits
Ville B:	N'exige pas les calculs de déperditions/gains de chaleur et les dimensions des conduits.

Des dérogations appréciables aux dispositions du code ont été relevées dans chacune des villes. On pourrait soutenir que les méthodes d'inspection davantage rigoureuses adoptées par la ville B compensaient en partie le processus d'approbation moins strict. L'étude démontre toutefois que la ville A n'applique pas forcément ses propres exigences en matière de délivrance de permis et que les méthodes d'inspection des bâtiments des deux villes n'ont pas permis de relever les failles de certaines installations. Dans la ville A, les exigences de calcul régissant les dimensions des conduits semblent entraîner la mise en place de conduits principaux de plus fortes dimensions que dans la ville B.

Même si les constructeurs, les entrepreneurs et les inspecteurs n'assuraient pas la conformité aux dispositions du code, les propriétaires-occupants ont formulé peu de plaintes au sujet de la qualité de leur installation.

D'après le nombre limité de maisons faisant l'objet de la présente étude, il semble qu'il y ait peu d'écart quant à la performance et à la perception de confort des systèmes de chauffage, de ventilation et de conditionnement d'air installés dans les deux villes, compte tenu des méthodes de délivrance des permis et d'inspection en vigueur.

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1.0 INTRODUCTION

The information and detail required for building permit applications varies dramatically from province to province and even within provinces. A contractor in one location may be faced with much different requirements in another jurisdiction only a few miles away.

This is particularly evident in the HVAC industry's involvement in residential house building. There are strong opinions on the part of building officials concerning the best way to ensure that HVAC systems are properly designed and installed. Some jurisdictions require a significant amount of assurance that the HVAC system has been designed prior to the issuance of a building permit. Other jurisdictions do not require as much "up front" design, but may (or may not) have more stringent requirements for approval of the HVAC contractor and for the inspection of the installed systems.

In this study, houses were inspected in two jurisdictions within the Province of Alberta. In addition, building officials in a third jurisdiction were interviewed.

The purpose of the study was to compare the resulting HVAC systems in jurisdictions with very different HVAC regulations and inspection requirements.

2.0 COMMENTARY ON PARAMETERS THAT DETERMINE THE PERFORMANCE OF A HEATING/VENTILATING SYSTEM

In order to compare residential HVAC systems, some basic performance parameters were identified as follows:

1. Design heat loss/gain for the house.
2. Furnace size installed compared with design heat loss for house.
3. Temperature rise of the installed furnace.
4. Proportional distribution of heat to all areas of the house.
5. Ventilation air flow.
6. Installed duct size.
7. Occupant perception of comfort, noise and air quality.

1. **Design Heat Loss/Gain**: The National Building Code references CAN/CSA-F280 for determining the required capacity of residential space heating and cooling appliances but states that alternative methods or standards conforming to good engineering practice are also permitted. For the purposes of this study, the installed systems were compared with the requirements of CAN/CSA-F280. As such, room by room heat loss calculations were done on each test house.

2. **Furnace Size**: Furnaces were considered to be properly sized if they had an output of between 100% and 140% of the design heat loss of the house.

3. **Temperature Rise**: The temperature rise of the installed furnace was measured and compared to the manufacturers' specifications.

4. **Proportional distribution of heat to all areas of the house.** The room by room heat loss calculated in (1.) above was used as the basis of comparing distribution. Supply and return air flows were measured in various rooms in each test house in order to determine the heat supply to each area.

5. **Ventilation air flow**: Section 9.32 of The National Building Code was used as the basis of comparison for the ventilation systems. Ventilation supply and exhaust air flow was measured and compared to the building code ventilation requirements.

6. **Installed duct size:** Trunk and branch duct sizes were compared with F280 duct designs for each house.

7. **Occupant perceptions:** Occupants were interviewed and asked about their perception of the comfort, noise levels and air quality.

3.0 HVAC PERMIT SUBMITTAL REQUIREMENTS AND INSPECTION PROCEDURES FOR CITY A AND CITY B

Three cities were included in the study because of their differing approach to the HVAC permit and inspection process as well as their close proximity to each other.

A brief review of the submittal requirements and inspection procedures follows:

City A:

Permit Application Stage:

- Submission of room by room heat loss calculations for all heating installations is required. The heating appliance selection shall be based on the heat loss calculation.
- The heating system supply, return air duct, heating outlets, grilles and registers shall be sized in accordance with good engineering practices.
- Prior to permit approval, heat loss calculations and appliance selection criteria is required to be submitted for confirmation (drawing or details indicating duct sizing and fittings must be provided). The City does not specify the format or require that the contractor use specific forms for this.

Inspection Stage:

- Inspectors are not required to be experienced in HVAC systems.
- At framing inspection, the furnace size is checked to make sure that it matches the size submitted with the permit.
- At final inspection:
    - Return air openings are checked to ensure that they exist.
    - A return air opening is allowed in the hall providing door undercuts are done properly.
    - Duct sizing is spot checked.
    - Outdoor air supply is checked.

City B:

Permit Application Stage:

- City B does not require the submission of heat loss calculations or duct designs.
- City B does require that the heating contractor employs a “Master” Sheet Metal Mechanic (defined as a journeyman with a minimum of 3 years experience). The contractor must present a Certificate of Qualifications.

Inspection Stage:

- Rough-in inspections are done (this typically involves a 30 minute inspection).
- Inspectors are required to be experienced in HVAC systems.
- Inspectors use rules of thumb to check furnace size.
- Prior to occupancy, the inspector:
    - Checks the ventilation system operation (including interconnections which may be required to operate the furnace blower when the principal exhaust fan switch is turned on).
    - Checks outdoor air duct size.
    - Checks return air grille locations.

City C: Building officials from a third city were interviewed during the early stages of this study. Although no test houses were included from this city, a brief summary of their permit and inspection process is presented:

- Permit Application Stage:
    - City C does not require submission of heat loss calculations or duct designs, except on a case by case basis e.g.: log homes or homes with unusually large window areas or large skylights.
    - City C does not require specific certification qualifications from heating contractors.
- Inspection Stage:
    - Furnace size (including altitude rating) is checked by the inspector.
    - Clearances to combustible materials are checked.
    - Return air openings are checked, ensuring there is one on each level.
    - The number of diffusers is noted in areas with unusually large amounts of glass.

- Ventilation system checks include:
  - Interconnections to other equipment if required.
  - Outdoor air intake size.
  - Make-up-air if required (particular attention is given to large exhaust devices).

4.0 DESCRIPTION OF HEATING SYSTEMS INCLUDED IN THE STUDY

Following is a brief description of the heating systems included in the study:

- 8 systems were included in the study (by 8 different builders).
- At least 4 different heating contractors were involved.
- The heating system in one home in City A and one home in City B was installed by the same heating contractor.
- Three heating contractors were not identified.
- The test houses were chosen randomly.
- All were single family homes.
- All were equipped with mid-efficient natural gas fired forced air furnaces.
- All furnaces were located in the basement.
- One had supplemental hydronic in-slab heat in the basement, although ventilation was supplied by the central forced air system.
- All homes in the study were occupied for at least one full heating season.
- Three different types of ventilation systems were observed:
    - Passive heat recovery ventilators (2 homes).
    - In-line fans connected to the return air of the furnace (5 homes).
    - Bathroom fan designated as the principal exhaust fan (1 home).

  In all cases the furnace blower was incorporated to draw outdoor air into the home. In most of the systems, the blower was interconnected to the principal exhaust fan.

5.0 GENERAL RESULTS, OBSERVATIONS, COMPARISONS AND CONCLUSIONS

Table 1 compares the calculated design heat loss for each test house to the installed furnace size. The generally accepted furnace capacity is considered to be from 100% to 140% of the house design heat loss. The calculated design heat loss was done using HRAI (Heating Refrigeration and Air Conditioning Institute of Canada) Residential Heating and Cooling Load Calculation Manual. All but one of the test houses had furnaces within the acceptable range. The one furnace outside the acceptable range was in City B. Temperature rise was checked on all systems and was found to be within the manufacturer's allowable range (Table 6).

The amount of heat required to be supplied to each area of the house is determined by the design heat loss from each room. City A requires that a room by room heat loss calculation be done such that the ducts can be sized to deliver the appropriate amount of heat. City B does not require that a room by room calculation be submitted. Some contractors in City B do room by room calculations and others do not. Table 2 compares the actual measured air flow supplied to selected rooms to the design air flow for the same rooms.

All of the systems tested exhibited low cumulative supply and return air flow rates at the grilles/diffusers when compared to the airflow measured at the return drop and supply plenum of the furnace. The difference is primarily due to duct leakage.

This comparison indicates that City A systems are delivering air to the selected rooms at a group average rate of approximately 69% of design rates, compared to City B systems are delivering air at a group average of approximately 44% of design rates. All test house systems were delivering less than design rates. It is interesting to note that the best test house in City B is still below the worst test house in City A in terms of delivered air compared to design target rates.

Table 3 compares measured return air flows to HRAI Air System Design air flows. This comparison does not show a significant difference between City A and City B. A major problem was found in the return air ducting of house B-1 (see House Specific Results – section 6.6). This alone could account for the difference between cities. No conclusions can be drawn based on measured return air flows.

Table 4 compares the actual duct sizes to those determined by HRAI Air System Design Manual and CSA Standard F280. This comparison does indicate that City A duct sizes are closer to design duct sizes on average than City B duct sizes.

Finally, table 5 indicates which ventilation systems meet the NBC minimum flow rates for principal exhaust fans (50% of TVC). Two out of five test homes in City A do not meet the minimum principal exhaust flow rates and one out of three City B test homes does not meet the minimum principal exhaust flow rate. Neither city appears to have a system that assures minimum ventilation rates are being met in all cases.

Significant deviations from code requirements were identified in each city. One could argue that the more rigorous inspection procedure in City B in part made up for the less stringent approval process. However, the study shows that City A does not necessarily enforce its own permit requirements and that the building inspection process in both cities missed flaws in some installations. The design requirements in City A appear to result in larger installed main ducts than in City B.

Despite the inability of builders, contractors and inspectors to ensure code compliance, homeowners had few complaints about the quality of their installations.

From the limited number of houses that were included in this study, it appears that there is little difference in the performance and perceived comfort levels of installed HVAC systems in the two cities with the current permit and inspection processes in place.

Table 1 - Furnace Size						
City A	CSA F280 design heat loss-Watts	Heating contractor's submitted heat loss-Watts	Furnace size submitted-Watts	Installed furnace output - Watts	Installed output/ submitted heat loss	Installed output/design heat loss
	(BTUH)	(BTUH)	(BTUH)	(BTUH)		
HOUSE A-1	13094 (44721)	11606 (39638)	14230 (48600)	13967 (47700)	120%	107%
HOUSE A-2	20652 (70534)	n/a (note 1)	28109 (96000)	28109 (96000)	n/a	136%
HOUSE A-3	19851 (67798)	n/a (note 1)	23453 (80100)	23453 (80100)	n/a	118%
HOUSE A-4	16676 (56955)	17529 (59866)	23424 (80000)	23424 (80000)	134%	140%
HOUSE A-5	18172 (62063)	15237 (52040)	23453 (80100)	23453 (80100)	154%	129%
City B						
HOUSE B-1	15645 (53433)	n/a	n/a	19085 (65180)	n/a	122%
HOUSE B-2	16717 (57095)	n/a	n/a	19085 (65180)	n/a	114%
HOUSE B-3	14374 (49090)	n/a	n/a	23453 (80100)	n/a	163%
Note 1: Although City A asked for heat loss calculations for this house, they were not on file						
City A: Requires submission of heat loss calculations and duct designs						
City B: Does not require submission of heat loss calculations or duct designs						

Table 2 - Room supply air flows

City A	Living Room/Foyer Design L/s	Living Room/Foyer Actual L/s	Master Bedroom Design L/s	Master Bedroom Actual L/s	Bedroom 2 Design L/s	Bedroom 2 Actual L/s	Bedroom 3 Design L/s	Bedroom 3 Actual L/s	Actual/ Design
HOUSE A-1	96	64	49	19	29	30	34	42	74.52%
HOUSE A-2	91	67	85	49	53	41			68.56%
HOUSE A-3	57	29	28	42	32	17	37	23	72.08%
HOUSE A-4	120	67	55	20	34	26	43	22	53.57%
HOUSE A-5	79	87	46	25	38	19	32	15	74.87%
Average									68.72%
City B									
HOUSE B-1	126	71	40	25	48	17			52.80%
HOUSE B-2	88	32	70	16	59	19	51	17	31.34%
HOUSE B-3	90	63	48	20	63	18	46	18	48.18%
Average									44.11%

City A: Requires submission of heat loss calculations and duct designs

City B: Does not require submission of heat loss calculations or duct designs

Table 3 - Room Return Air Flows

	Room								
City A	Living Room/Foyer		Master Bedroom		Bedroom 2		Bedroom 3		
	Design L/s	Actual L/s	Design L/s	Actual L/s	Design L/s	Actual L/s	Design L/s	Actual L/s	ACTUAL/ DESIGN
HOUSE A-1	152	94	110	41	105	71			56.13%
HOUSE A-2	171	167	169	83	173	81			64.52%
HOUSE A-3	269	204	207	103	27	0	27	0	57.92%
HOUSE A-4	161	249	89	62	74	65	85	64	107.58%
HOUSE A-5	138	132	59	33	100	19	118	10	46.75%
	Average								66.58%
City B									
HOUSE B-1	189	70	165	17	125	11			20.46%
HOUSE B-2	226	223	119	22	114	65	107	57	64.84%
HOUSE B-3	192	161	135	57	102	57	76	55	65.35%
	Average								50.22%

City A: Requires heat loss/gain calculations and duct design

City B: Does not require heat loss/gain calculations and duct design

Table 4 - Supply Trunk Sizes

City A		F280 Main Supply Trunk(mm)	Equiv. Area(m2)	As Installed Main Supply Trunk(mm)	Equiv. Area(m2)	Equivalent area Correlation(1)
HOUSE A-1	Trunk A	356 x 203	0.067	230 x 203	0.046	69%
	Trunk B	254 x 203	0.051	230 x 203	0.046	90%
HOUSE A-2	Trunk A	610 x 203	0.107	457 x 203	0.086	80%
	Trunk B	330 x 203	0.067	305 x203	0.062	93%
HOUSE A-3	Trunk A	533 x 203	0.099	356 x 203	0.067	68%
	Trunk B	203 x 203	0.037	305 x203	0.058	158%
HOUSE A-4	Trunk A	533 x 203	0.099	305 x203	0.058	59%
	Trunk B	533 x 203	0.099	254 x 203	0.051	52%
HOUSE A-5	Trunk A	610 x 203	0.107	457 x 203	0.086	80%
	Trunk B	533 x 203	0.099	457 x 203	0.086	87%
Average Installed Equiv.duct area/Design Equiv. area						83.53%
City B						
HOUSE B-1	Trunk A	533 x 203	0.099	356 x 203	0.067	68%
HOUSE B-2	Trunk A	457 x 203	0.086	356 x 203	0.067	78%
HOUSE B-3	Trunk A	711 x 203	0.122	381 x 203	0.070	57%
Average Installed Equiv.duct area/Design Equiv.area						67.65%

Note 1: compares installed equivalent duct area with F280 design equivalent area

City A: Requires submission of heat loss calculations and duct designs

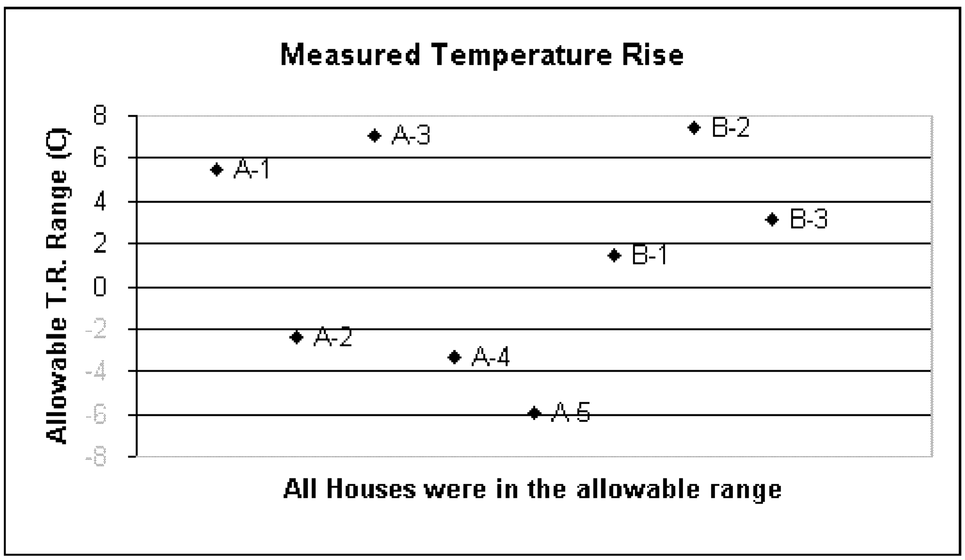
City B: Does not require submission of heat loss calculations or duct designs

Table 5 - Ventilation

	Total Ventilaton Capacity (L/s) (note 1)	Measured Principal Exhaust flow rate (L/s)	Meets NBC Principal exhaust flow minimum requirements?
City A			
HOUSE A-1	50	22	NO
HOUSE A-2	55	34	YES
HOUSE A-3	55	11	NO
HOUSE A-4	65	37	YES
HOUSE A-5	55	40	YES
City B			
HOUSE B-1	50	31	YES
HOUSE B-2	55	17	NO
HOUSE B-3	55	38	YES
City A: Requires heat loss/gain calculations and duct design			
City B: Does not require heat loss/gain calculations and duct design			
Note 1: As specified in NBC Section 9.32			

Table 6 - Temperature Rise

City A		Manufacturer's Allowable Range		Measured Temp. Rise	Over/Under Midpoint
		Minimum	Maximum		
		DEGREES CELCIUS	DEGREES CELCIUS	DEGREES CELCIUS	DEGREES CELCIUS
HOUSE	A-1	22.2	38.9	36	5.45
HOUSE	A-2	25.0	41.7	31	-2.35
HOUSE	A-3	30.6	47.2	46	7.10
HOUSE	A-4	25.0	41.7	30	-3.35
HOUSE	A-5	30.6	47.2	33	-5.90
City B					
HOUSE	B-1	22.2	38.9	32	1.45
HOUSE	B-2	22.2	38.9	38	7.45
HOUSE	B-3	30.6	47.2	42	3.10



6.0 HOUSE SPECIFIC RESULTS, OBSERVATIONS AND CONCLUSIONS

6.1 HOUSE A-1

- Raised bungalow.
- 1915 ft2 total floor area.
- HVAC workmanship was better than average.
- Ventilation: Bath fan as principal exhaust fan. Ventilation flow rates did not meet NBC requirements for principal exhaust fan. Principal exhaust fan was not interconnected to furnace blower.
- Homeowner comments: No concerns with comfort, noise, or air quality.

6.2 HOUSE A-2

- Bungalow with fully developed basement.
- 3459 ft2 total floor area.
- HVAC workmanship was above average.
- Ventilation: in-line fan drawing air from R/A (see Pic.A-2a); Ventilation flow rates meet NBC, but principal exhaust fan is not interconnected with furnace blower.
- Homeowner comments: No concerns with comfort, noise, or air quality, however, they did comment about the master bedroom area being cool at times. Flow measurements indicated close to design air flow to the master bedroom. Return air flow was below design.

6.3 HOUSE A-3

- Bungalow with fully developed basement.
- 3234 ft2 total floor area.
- HVAC workmanship was average except:
  - 2 lower bedrooms and one hall R/A grille had zero flow.
  - HRV ducts not properly insulated.
- Ventilation: Passive HRV (see pic A-3a). Principal exhaust flow was below NBC ventilation requirements. Intake and Exhaust hoods were only 20" apart.
- Return air flows from 2 bedrooms and hall in basement were zero.
- Homeowner comments: No major concerns with comfort, noise, or air quality, however, they did comment about the nook area being cool at times. Flow measurements did confirm that the supply air to this area was about 25% below design.

6.4 HOUSE A-4

- 2 storey home.
- 2342 ft2 total floor area.
- HVAC workmanship was better than average.

- This house had the most complete submission (*Quality First* heat loss and duct design), however, the installer did not completely follow the design. The design called for two -12 x 8 trunks but the actual installed trunks were 12 x 8 and 10 x 8. As well, the blower speed/cfm called for in the design was med-lo(840cfm) and the installed speed/cfm was med-hi(1297 cfm). The measured temperature rise was on the low end of the allowable range. This system would likely perform better if set at the lower speed (as per the submitted design).
- Homeowner comments: No concerns with comfort, noise, or air quality.

6.5 HOUSE A-5

- 2 storey home.
- 2300 ft2 total floor area.
- HVAC workmanship was above average.
- Air flows on the upper level of this house were significantly below design rates. The house design was fairly open such that duct corridors were not conveniently located in a way that would facilitate efficient ductwork. The ducts were not sized to allow for the tortuous paths that the ductwork had to follow to get to the upper level and this resulted in excessive restriction to the air flow.
- Ventilation: in-line fan. Ventilation flow rates meet NBC requirements.
- Homeowner comments: No concerns with comfort, noise, or air quality.

6.6 HOUSE B-1

- Split level home.
- 2230 ft2 total floor area.
- HVAC workmanship was about average except as noted below.
- During testing of this house, return air measurements indicated extremely low air flows from upper level and family room grilles. The measurements were re-checked. Finally, it was discovered that the end of a 19.2" return air joist run had been forgotten. The result was that most of the furnace return air was being drawn from the furnace room. The return air flow rates measured will change significantly once the heating contractor corrects this situation. The homeowner had commented that the family room tended to be cooler than desired, but no major concerns were expressed about the other rooms with low return air flows. The Room Return Air Flow (table 3) is skewed by this problem.
- Ventilation: in-line fan drawing from R/A duct. Meets NBC ventilation requirements in terms of flow rates.
- Homeowner comments: No major concerns with comfort, noise, or air quality, however, they did comment on the recreation room being slightly cooler (likely a result of the above joist return problem).

6.7 HOUSE B-2

- Two storey house.
- 2350 ft2 total floor area.
- HVAC workmanship was below average on the heating system, notably the return air panning (see picture B-2a).
- Ventilation: passive HRV.
    - Ventilation principal exhaust flow rate was below NBC code (50% of TVC).
- Homeowner comments: No concerns with comfort, noise, or air quality.

6.8 HOUSE B-3

- Two storey house.
- 2274 ft2 total floor area.
- HVAC workmanship was better than average.
- Ventilation: in-line fan drawing exhaust from R/A duct. Meets NBC ventilation flow rates.
- Homeowner comments: No concerns with comfort, noise, or air quality.

7.0 CONCLUSIONS

The study resulted in some conclusions that were not expected by the writer. It was anticipated that better installations would be observed in the city with requirements for heat loss calculations and duct design. While most of the data collected in this study does indicate slightly better installations, it does not appear that installations differ significantly in terms of performance or occupant perceptions of comfort compared to the city that does not require heat loss calculations and duct design.

An effort was made to randomly select homes built in different parts of each city by different builders and with different installers. It should be pointed out that only 5 houses were tested in City A and 3 houses in City B. A larger sampling could produce different results.

Significant deviations from code requirements were identified in each city. It could be argued that the more rigorous inspection procedure in City B in part made up for the less stringent approval process. However, the study shows that City A does not necessarily enforce its own permit requirements and that the building inspection process in both cities missed flaws in some installations.

Some reasons for the surprising results could be:

1. The documents submitted by contractors in City A varied significantly in the amount of information included and in its format:
   a. There were 4 different types of forms submitted for the 5 houses tested in City A.
   b. Only 1 out of the 5 submissions included complete trunk sizes (some forms had spaces for this, but the contractor left them blank).
   c. 3 out of 5 submissions had incomplete information on branch sizes.

   It would be worth using one form such that all heating contractors would supply the same type of information in the same format.

2. The information provided in the submissions for City A did not include drawings of the duct layouts. In one case a schematic layout was provided, but there was no indication of the supply or return paths in the actual house. As a result, the actual layout could not be checked by the authorities in City A at the time of permit application for any obvious problems. In one notable instance, the supply and return air flows to upper levels were found to be much lower than required. This was likely due to the difficult routes that the heating contractor had to follow to supply the upper levels of the house. The submitted information was not adequate to allow authorities to flag this at time of application.

3. The inspection process was different in the two cities. In particular, the inspectors in City B (which did not require heat loss/duct design submittals) are required to be experienced in HVAC systems. Most are journeymen sheet metal mechanics.

It appears that the process is still evolving in City A. There has been a steep learning curve (and a certain amount of resistance) for the local contractors because this is one of the first areas in this region to require heat loss calculations and duct design on a routine basis.

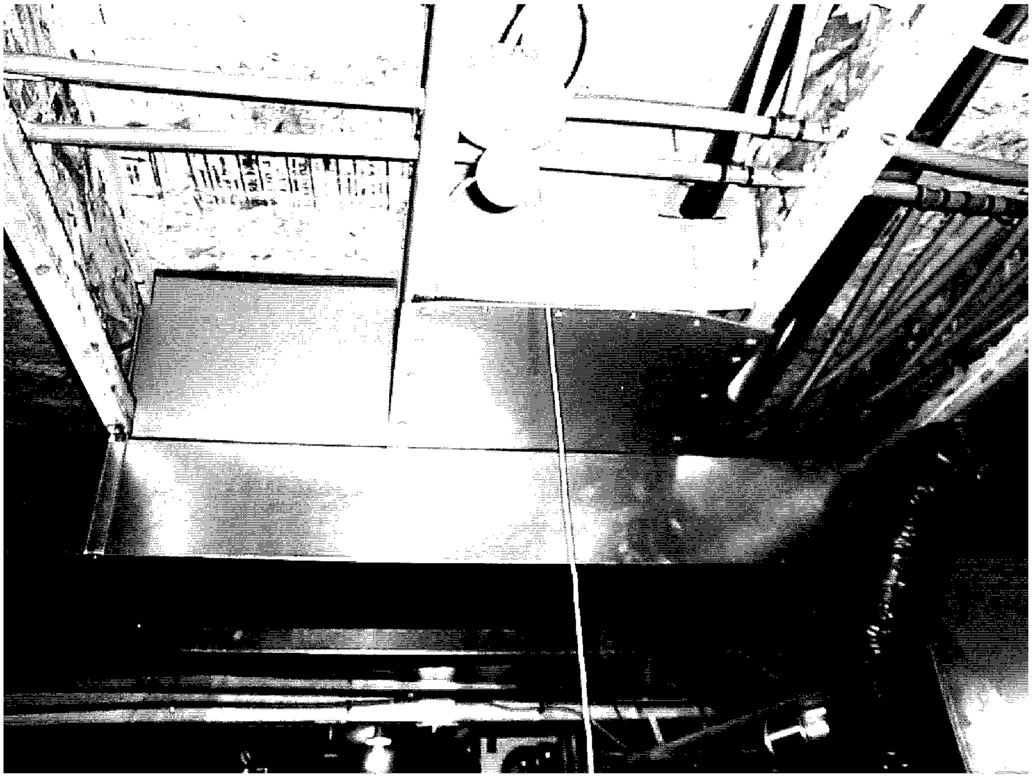
There are many potential benefits from a process that requires heat loss calculations and duct design at the permit stage, however, the information supplied in these documents must be:

1. Complete
2. Presented in a consistent and readable format.
3. Reviewed by an experienced person such that deficiencies can be detected prior to the start of construction.
4. Used by the inspector after construction to ensure that the system was installed as designed.

Other jurisdictions in Canada (such as Ontario) have been requiring heat loss calculations and duct sizing layouts for several years. It would be interesting to do a similar comparison in jurisdictions where procedures have been well established to see if the resulting installations show a significant difference in performance compared to jurisdictions that do not require heat loss calculations or duct layouts.

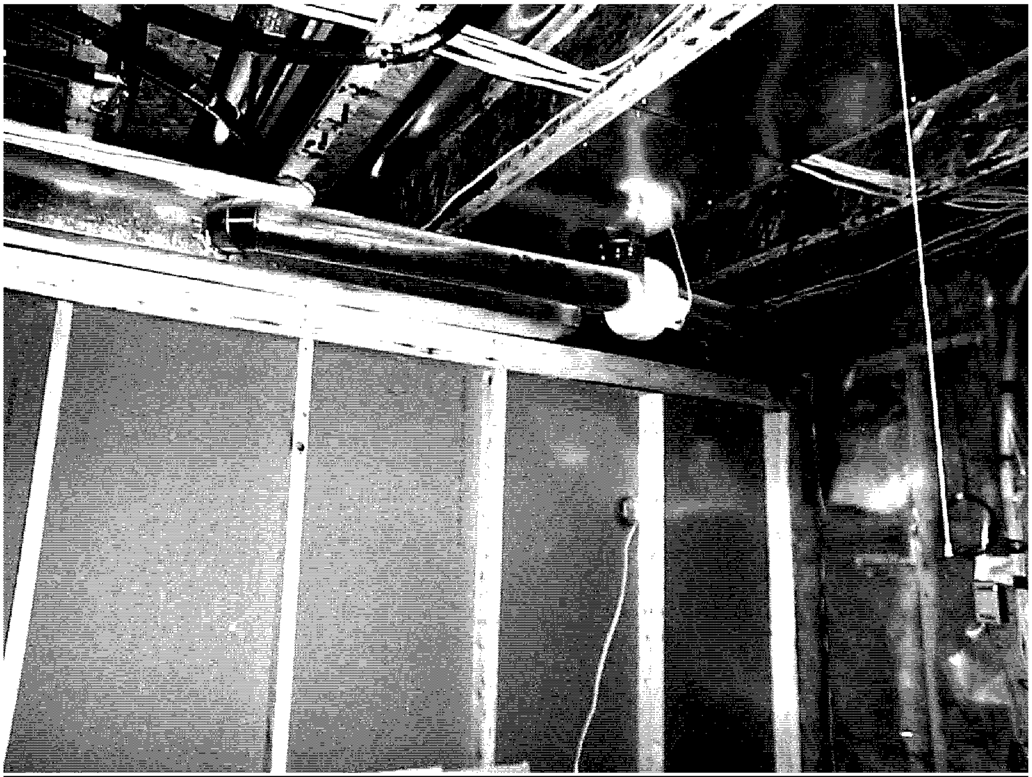
Despite the inability of builders, contractors and inspectors to ensure code compliance, homeowners had few complaints about the quality of their installations in both City A and City B.

Picture 1 **(Workmanship)**



Note the gaps between the joist and the joist panning material. Also, note the poor fit around the plumbing pipe.

Picture 2 (In-line fan as Principal exhaust fan)



Shows an in-line fan connected to the return air duct of the forced air system.

Picture 3 (Passive HRV ventilation system):

Note the poor sealing of the insulation on the cold side ducts connected to the HRV.