



*Advanced Fluid Mechanics
Research group*

Report

**Preliminary Estimate for
Energy Saving with
*The Bennett Garbage Chute***

prepared for

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London, Ontario

by

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Summary

The theoretical principles for calculating heat loss from a garbage chute are presented based on ASHRAE standards. The principle modes of heat loss are conduction through the walls, leakage through chute opening and convection losses due to updraft in the chute. Open or closed trap door operation will affect both conduction and convection losses. Sample calculations are performed for 10, 20, and 40 floor buildings for cold winter and hot summer conditions in London, Ontario in an urban setting. It is shown that *The Bennett* may result in as much as 18% and 10% reduction in energy consumption for peak winter and summer conditions, respectively.

Nomenclature

A	Surface area
D	Duct diameter
g	gravity acceleration
h	Convection heat transfer coefficient
H	Building height
i	Enthalpy
k	Conduction heat transfer coefficient
N_d	Number of chute door opening per floor per hour
N_f	number of floors in the building
Nu	Nusselt number
P	pressure
Pr	Prandtl number
R	Thermal resistance
Ra	Rayleigh number
Re	Reynolds number
t_d	Average chute door opening
T	Temperature
U	Overall heat transfer coefficient
V	Volume flow rate
W	Velocity
w	Wall
Z	Elevation
ΔT	Temperature difference
\dot{Q}	Heat transfer rate
Δx	Thickness
ρ	Density
β	Coefficient of thermal expansion

ν Kinematic viscosity
 ω Humidity Ratio
 Σ Summation

Scope

The Bennett is designed to operate with a closed trap door under most conditions. This design reduces the updraft in the garbage chute. This reduction in air motion will result in lower energy transfer between the building walls and exterior. In this study, the principles for evaluating energy losses to a garbage chute will be outlined based on ASHRAE standards [1]. Heat losses for open and closed trap door operation will be compared for a winter day (exterior temperature 1°F, indoor temperature 70°F) and a summer day (exterior temperature 87°F, indoor temperature 78°F).

1. Background

The Bennett garbage chute of *Samuel Bennett Manufacturing Inc.* is distinct from other commercial chutes because of it is designed to operate with a closed trap door. By keeping the trap door closed, the updraft of air is reduced and it is expected that the heat transfer from the building walls to the exterior will be reduced. In this report, the maximum expected heat loss reduction will be estimated for two identical chute designs, one operated with the trap door open and the other with the trap door closed.

In estimating the heat loss from the building, it is assumed that when the trap door is open, only forced heat convection will occur in the chute. With a closed trap door, the effect of natural convection will be the principal mode of heat transfer. Second, the insulating value of building materials will be estimated for a common wall construction.

In this report, the mathematical relationships required to describe the different heat transfer modes are described. Subsequently, the heat loss is estimated for a typical 10, 20 and 40 floor building for a cold winter day and a warm summer day assuming: (i) an open trap door and (ii) a closed trap door. All other conditions are held constant. The report conclusion addresses some of the limitations in this comparison. An overview of future work is also provided.

2. Heat Transfer Principles

The main sources of heat loss through the garbage chute are:

- (i) Conduction through the walls.
- (ii) Leakage through the chute door.
- (iii) Convection due to air flow in the chute.

Detailed definitions and theoretical models describing these mechanisms can be found in Ref. [1].

2.1 Conduction through the walls

Heat transfer through walls is due to the temperature difference between the two faces of a wall. It depends on the heat resistance of the wall material, R , and the temperature difference between the wall faces, ΔT_w , according to

$$\dot{Q}_{\text{cond}} = U A \Delta T_w$$

Where \dot{Q}_{cond} is the heat transfer (Btu/hr) and A is the exposed surface area (ft²) of the wall and U is the overall heat transfer coefficient (Btu/hr.ft².F):

$$\frac{1}{U} = R$$

The heat resistance of the wall materials is given by:

$$R = \frac{\Delta x}{k}$$

where Δx is the wall thickness and k is the conduction coefficient, which is a material property.

Most wall constructions are layered, usually consisting of concrete, an air gap and chute lining. In this situation:

$$\frac{1}{U} = \sum_w R_w$$
$$\frac{1}{U} = R_{\text{concrete}} + R_{\text{air}} + R_{\text{chute lining}}$$

and Σ denotes the summation of the thermal resistance for each wall layer, w . The total heat loss is then given by:

$$\dot{Q}_{\text{cond}} = U A \Delta T_w$$

where ΔT_w now represents the temperature difference between the inner and the outer wall faces.

2.2 Infiltration through chute doors

The amount of heat loss due to infiltration is directly proportional to the total volume of air escaping the building through the chute in a given period of time. The building corridors are supplied with conditioned fresh air at a rate of 15 cfm/person/floor (see Ref. [1]) to maintain corridors at the design indoor temperature (winter 70°F, summer 78°F). For each floor, air is provided at a rate of v (cfm):

$$v = (15 \text{ cfm /person/floor}) \times \text{number of persons per floor}$$

Thus, during each chute door opening, heated air infiltrates through the door at a rate of v .

The volume of conditioned air lost through the chute, V for each floor is:

$$V = v \times t_d \times N_d \times N_f$$

where t_d is the average (typical) time a chute door is opened, N_d is the number of times the chute door is opened (openings per hour) and N_f is the number of floors in the building. The heat loss due to infiltration, $\dot{Q}_{\text{infiltration}}$, is then calculated from the volume of infiltrated air and its heat content:

$$\dot{Q}_{\text{infiltration}} = V \times \rho \times i$$

where ρ is the density (lbm/ft³) and i is the enthalpy (Btu/lbm) of air, which can be calculated:

$$i = 0.24T + \omega (1061.2 + 0.2444T)$$

where ω is the humidity ratio of the indoor air (lbm/lbma), and T the indoor temperature in °F.

2.3 Convection heat transfer

Heat transfer due to convection, \dot{Q}_{conv} , is calculated using Newton's law of cooling

$$\dot{Q}_{\text{conv}} = h A \Delta T_{\text{air}}$$

where A is the exposed wall surface area, ΔT_{air} is the temperature difference between the wall surface and air stream and h is the convective heat transfer coefficient. The parameter h depends on the material properties of the air, the speed of the flow and the mode of convective heat transfer: either forced or natural convection.

Forced convection: occurs due to updraft and h is calculated according to:

$$\text{Nu} = \frac{hD}{k_f} = 0.17 \text{Re}_f^{0.33} \text{Pr}_f^{0.4} \left(\frac{\text{Pr}_f}{\text{Pr}_w} \right)^{0.25} \quad \text{for laminar flow (chute opened, } \text{Re}_f < 2,500)$$

$$\text{Nu} = \frac{hD}{k_f} = 0.023 \text{Re}_f^{0.8} \text{Pr}_f^{0.4} \left(\frac{\text{Pr}_f}{\text{Pr}_w} \right)^{0.25} \quad \text{for turbulent flow (chute opened, } \text{Re}_f > 2,500)$$

Where Nu is the Nusselt number, Re is the Reynolds number, and k_f is the air conduction heat transfer coefficient. The Prandtl number, Pr , is a material property of air: the subscripts f and w denote that Pr is calculated at the air stream and inner wall temperatures, respectively. The Reynolds number is given by:

$$\text{Re}_f = \frac{DW}{\nu}$$

where W is the air stream velocity in the chute, ν is the kinematic viscosity of air and D is the chute hydraulic diameter.

The air stream velocity in the chute is due to the difference in pressure between the top and bottom of the chute. This pressure difference is a result of exterior wind conditions and barometric variation due to elevation. The barometric variation is given by Ref. [3]:

$$P_5 - P_4 = (-0.001025 \times H) \times 70.512 \quad (\text{lbf/ft}^2)$$

where $P_5 - P_4$ is the pressure difference between the top and bottom of the building and H is the height (ft) of the building. Then the air velocity (ft/s) at any elevation is then calculated by [4]:

$$W = \sqrt{\frac{2}{\rho} [(P_4 - P_5) + \frac{1}{2}\rho W_{\text{wind}}^2 - \rho g H]}$$

where W_{wind} is the exterior wind speed (ft/s) and g is the acceleration due to gravity.

Natural convection is a result of air motion due to buoyancy. It occurs inside the building (corridor) at all times and in the chute when the trap door is shut. The heat transfer coefficient due to natural convection is related (see Ref. [2]) through:

$$\text{Nu} = \frac{h D}{k_f} = C \text{Ra}^n$$

where Ra is the Rayleigh number [2]:

$$\text{Ra} = \frac{g\beta}{\nu^2} \text{Pr} D^3 \Delta T_{\text{air}}$$

and β is the coefficient of thermal expansion ($1/^\circ\text{R}$).

The values for h inside the building are determined from the tabulated ASHRAE standards [1]. For the chute, the coefficients C and n are given by Ref. [2]:

Ra	C	n
<0.001	0.50	0
0.001-500	1.18	0.125
500- 2×10^7	0.54	0.25
2×10^7 - 10^{13}	0.135	0.333

2.4 Overall heat transfer calculation:

The combined conduction and convection heat loss can be obtained directly through:

$$\frac{1}{U} = \sum_w R_w + \frac{1}{h}$$

so that heat is lost at a rate of

$$\dot{Q}_T = A U \Delta T_T \quad (\text{Btu/hr})$$

where ΔT_T is the temperature difference between corridor and chute air temperature.

The total heat loss per day is then obtained by combining the heat loss rates due to conduction, convection and infiltration according to:

$$Q_T = \left[\dot{Q}_T + \dot{Q}_{\text{infiltration}} \right] \times 24 \frac{\text{hour}}{\text{day}}$$

3. Calculation for winter and summer heat loss

In this section, sample calculations are shown for determining the heat losses from a typical 10-floor building for a winter condition with the trap door open. The predicted values for winter and summer conditions, for open and closed trap door, are summarized in Table 3.1 for 10, 20 and 40 story buildings.

The calculations were carried out using the following assumptions:

1. Winter conditions (ASHRAE –standard [1]):
 - outside temperature = 1°F
 - inside temperature = 70°F
 - wind speed = 20km/hr (18.2ft/s)
2. Summer conditions (ASHRAE –standard [1]):
 - outside temperature = 87°F
 - inside temperature = 78°F
 - wind speed = 20km/hr (18.2ft/s)
3. Height of each floor = 10ft.
4. Each floor has six apartments.
5. Each apartment is occupied by four persons.
6. Chute is opened for 5sec.
7. Chute opening schedule:
 - 6:00 – 9:00 every 15minutes per floor
 - 9:00 – 16:00 every 30 minutes per floor
 - 16:00 – 20:00 every 15 minutes per floor
 - 20:00 - 6:00 every hour per floor
8. Steady state conditions prevail.
9. Air temperature in the main garbage room equals to the temperature outside.
10. The changes or air density due to elevation are considered negligible. It is thus assumed the airflow speed will be the same at every floor along the chute.
11. During open trap door operation, the change of air density due to heating is considered negligible and the updraft air speed is thus considered constant along the chute.

3.1 Conduction losses

In order to calculate the heat losses to the garbage chute, we need to specify the heat resistance properties of the building materials. The chute cross-section is shown schematically in Figure 1. It consists of four walls and a duct lining separated by a 9-inch air gap. The chute is taken to be a square duct of 26 by 26 inches which is equivalent to a 24 inch hydraulic diameter, D.

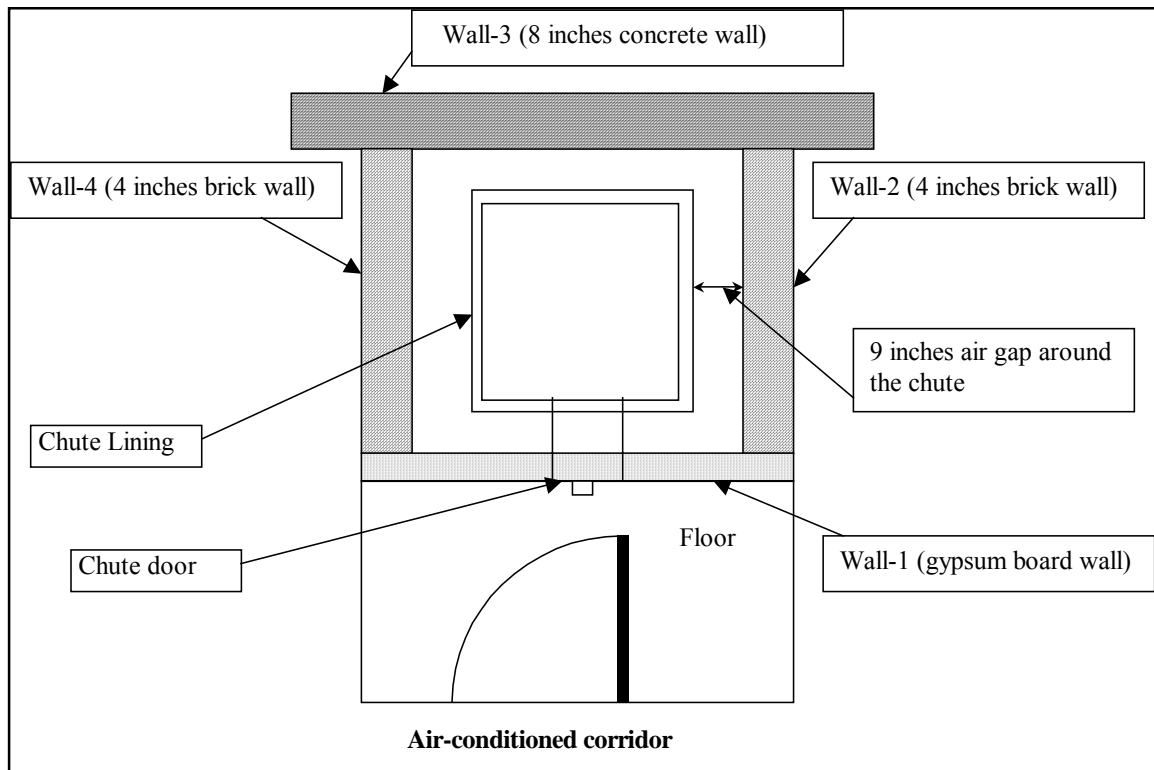


Figure 1 Schematic shows the chute with the surrounding walls

3.1.1 Resistance of Concrete wall (wall-3)

The wall between the apartments and the shaft containing the chute is made of concrete. We will use the tabulated values for sand gravel or stone aggregate concrete [1]:

$$\begin{aligned} \rho &= 150 \text{ lb/ft}^3 \\ \Delta x &= 8 \text{ inches} \\ k &= 15 \text{ Btu-in/hr.ft}^2.\text{°F} \\ R_{\text{concrete}} &= \frac{\Delta x}{k} = \frac{8}{15} \text{ hr.ft}^2.\text{°F/Btu} \end{aligned}$$

3.1.2 Resistance of Block walls (wall-2 and wall-4)

The wall between the chute shaft and the corridors is made of bricks. Fired clay brick will be used in the calculation. The values for the brick properties listed below [1]:

$$\begin{aligned}\rho &= 120 \text{ lb/ft}^3 \\ \Delta x &= 4 \text{ inches} \\ k &= 7 \text{ Btu-in/hr.ft}^2.\text{°F} \\ R_{\text{Brick}} &= \frac{\Delta x}{k} = \frac{4}{7} \text{ hr.ft}^2.\text{°F/Btu}\end{aligned}$$

3.1.3 Resistance of Chute wall (wall-1)

The wall between the garbage room and the chute shaft is made of gypsum board. Gypsum board of 3/8 inches thick with 4 inches air gap will be considered [1]

$$G_{\text{gypsum wall}} = 2.91 \text{ (hr.ft}^2.\text{°F)/Btu}$$

3.1.4 Resistance due to 9-inch air gap

The chute is placed in the centre of the shaft with about 9 inches clearance from all sides. The value for the heat transfer resistance through this air gap is obtained from [1] as:

$$R_{\text{gap}} = 2.73 \text{ hr.ft}^2.\text{°F/Btu}$$

3.1.5 Garbage chute lining

The chute lining is assumed to be sheet metal (steel) of thickness 0.2 inches [1].

$$\begin{aligned}k &= 314 \text{ (Btu-in)/(hr.ft}^2.\text{F)} \\ \rho &= 489 \text{ lb/ft}^3 \\ R_{\text{chute}} &= 0.0001592 \text{ hr.ft}^2.\text{°F/Btu}\end{aligned}$$

3.2 Infiltration through chute doors

For each floor, the amount of conditioned air (heated in winter and cooled in summer) is:
15 cfm/person/floor:

$$V = (15 \text{ cfm/person/floor}) \times t_d \times N_d \times N_F$$

- t_d : Average chute door opening (5 sec/opening)
 N_d : Number of opening per floor per hour (see assumptions #10)
 N_F : Number of floors (10).

Then for the case of a 10 floor building with open trap (see assumption #4, 5, 6 and 7):

$$6:00 - 9:00 \quad V-I = (15 \text{ cfm} \times 4 \times 6) \times (5 \text{ s}/60 \text{ s/min}) \times (4/\text{hr}) \times (10 \text{ floors}) = 1200 \text{ ft}^3/\text{hr}$$

$$9:00 - 16:00 \quad V-II = (15 \text{ cfm} \times 4 \times 6) \times (5 \text{ s}/60 \text{ s/min}) \times (2/\text{hr}) \times (10 \text{ floors}) = 600 \text{ ft}^3/\text{hr}$$

$$16:00 - 20:00 \quad V-III = (15 \text{ cfm} \times 4 \times 6) \times (5 \text{ s}/60 \text{ s/min}) \times (4/\text{hr}) \times (10 \text{ floors}) = 1200 \text{ ft}^3/\text{hr}$$

$$20:00 - 6:00 \quad V-IV = (15 \text{ cfm} \times 4 \times 6) \times (5 \text{ s}/60 \text{ s/min}) \times (1/\text{hr}) \times (10 \text{ floors}) = 300 \text{ ft}^3/\text{hr}$$

Total air infiltrates at a rate of:

$$V = \left[1200 \frac{\text{ft}^3}{\text{hr}} \cdot \frac{3 \text{ hr}}{\text{day}} + 600 \frac{\text{ft}^3}{\text{hr}} \cdot \frac{7 \text{ hr}}{\text{day}} + 1200 \frac{\text{ft}^3}{\text{hr}} \cdot \frac{4 \text{ hr}}{\text{day}} + 300 \frac{\text{ft}^3}{\text{hr}} \cdot \frac{10 \text{ hr}}{\text{day}} \right] \times \frac{1 \text{ day}}{24 \text{ hr}} = 650 \text{ ft}^3 / \text{hr} .$$

And the heat loss is given by:

$$\dot{Q}_{\text{infiltration}} = V \times \rho \times i$$

and

$$i = 0.24 T + \omega (1061.2 + 0.2444 T)$$

The value of T is 70°F in winter and 78°F in summer.

The value of ω is 0.006 lbv/lba in winter and 0.01 lbv/lba in summer.

The value of ρ is 0.074 lbm/ft³ in winter and 0.073 lbm/ft³ in summer.

Then for the case of 10 floors building in winter: $i = 23.27 \text{ Btu/lbm}$

$$\dot{Q}_{\text{infiltration}} = 650 \text{ ft}^3/\text{hr} \times 0.074 \times 23.27 = 1119.3 \text{ Btu/hr}$$

3.3 Convective heat transfer

3.3.1 Forced convection (open trap)

In order to calculate the values of the Reynolds number, the velocity of the air through the chute has to be calculated. The airflow is due to pressure difference between the garbage room and roof, $P_4 - P_5$.

We will call the condition outside the garbage room 4 and 5 is the condition at any elevation.

$$P_5 - P_4 = [-0.001025xH] \times 70.512 \quad (\text{lbf/ft}^2)$$

$$H = 10 \text{ (floors)} \times (10 \text{ ft/floor}) = 100 \text{ ft}$$

$$G = 32.17 \text{ ft/sec}^2$$

$$\rho = 0.074 \text{ lbf/ft}^3$$

$$W_{\text{wind}} = 20 \text{ (km/hr)} = 18.2 \text{ ft/sec.}$$

W = velocity at any elevation in the chute.

Then

$$W = \sqrt{\frac{2}{\rho} [(P_4 - P_5) + \frac{1}{2}\rho W_{\text{wind}}^2 - \rho gH]}$$

$$W = 13.14 \text{ ft/sec.}$$

Calculation of Reynolds number:

$$\text{Re}_f = \frac{DW}{\nu} = \frac{2 \times 13.14}{1.52 \times 10^{-4}} = 1.73 \times 10^5$$

Since $\text{Re}_f > 2500$, then the flow is turbulent. Then Nu can be calculated from

$$\text{Nu} = \frac{hD}{k_f} = 0.023 \text{Re}_f^{0.8} \text{Pr}_f^{0.4} \left(\frac{\text{Pr}_f}{\text{Pr}_w} \right)^{0.25}$$

$$k_f = 0.0137 \quad \text{Btu/(hr.ft}^2\text{.F)}$$

$$\text{Pr} = 0.71$$

$$\nu = 1.52 \times 10^{-4} \quad \text{ft}^2\text{/sec.}$$

$$\text{Nu} = 310.93$$

$$\text{and } h = \text{Nu} \times (k_f/D) = 310.93 \times (0.0137 / 2) = 2.13 \text{ Btu/(hr.ft}^2\text{.}^\circ\text{F)}$$

the value of the convective heat transfer coefficient with an open trap $h_{\text{chute}}=2.13 \text{ Btu}/(\text{hr}.\text{ft}^2.\text{°F})$

3.3.2 Natural convection (trap closed)

In the natural convection case when the trap is closed the Nu is calculated from:

$$\text{Nu} = \frac{h D}{k_f} = C \text{Ra}^n$$

and Ra number:

$$\text{Ra} = \frac{g\beta}{\nu^2} \text{Pr} D^3 \Delta T_{\text{air}}$$

$$\begin{aligned} \beta &= 0.00196 && 1/\text{°R} \\ g &= 32.17 && \text{ft}/\text{sec}^2. \\ k_f &= 0.0137 && \text{Btu}/(\text{hr}.\text{ft}.\text{°F}) \\ \text{Pr} &= 0.71 \\ C &= 0.135 \\ n &= 0.333 \\ \Delta T_{\text{air}} &= 70-1 = 69\text{°F} \end{aligned}$$

The calculation for this case:

$$\begin{aligned} \text{Ra} &= 1.07 \times 10^9 \\ \text{Nu} &= 0.135 \times (1.07 \times 10^9)^{0.333} = 137.5 \\ h &= \text{Nu} \times (k_f/D) = 137.15 \times (0.0137 / 2) = 0.94 \text{ Btu}/(\text{hr}.\text{ft}^2.\text{°F}) \end{aligned}$$

3.4 Overall heat transfer

3.4.1 Forced convection (open trap)

The overall heat transfer coefficients for different walls:

$$\begin{aligned} 1/U_{\text{concrete side}} &= R_{\text{concrete}} + R_{\text{gap}} + R_{\text{chute}} + 1/h_{\text{chute}} + 1/h_{\text{inside}} \\ 1/U_{\text{concrete side}} &= 0.533 + 2.73 + 0.0001592 + (1/2.13) + (1/1.46) = 4.42 \\ U_{\text{concrete side}} &= 1/4.42 = 0.23 \text{ Btu}/(\text{hr}.\text{ft}^2.\text{°F}) \\ 1/U_{\text{brick side}} &= R_{\text{brick}} + R_{\text{gap}} + R_{\text{chute}} + 1/h_{\text{chute}} + 1/h_{\text{inside}} \end{aligned}$$

$$1/U_{\text{brick side}} = 0.571+2.73+0.0001592+(1/2.3)+(1/1.46) = 4.46$$

$$U_{\text{brick side}} = 1/4.46 = 0.22 \text{ Btu}/(\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F})$$

$$1/U_{\text{gypsum wall}} = R_{\text{gypsum wall}}+R_{\text{gap}}+R_{\text{chute}}+ 1/h_{\text{chute}}+1/h_{\text{inside}}$$

$$1/U_{\text{gypsum wall}} = 2.91+2.73+0.0001592+(1/2.13)+(1/1.46) = 6.78$$

$$U_{\text{gypsum wall}} = 1/6.78 = 0.15 \text{ Btu}/(\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F})$$

and then

$$\dot{Q}_w = \sum A U (T_{\text{inside}} - T_{\text{outside}})$$

$$\dot{Q}_{\text{concrete side}} = \left(\frac{26+18}{12} \frac{\text{ft}}{\text{floor}}\right) \times (10\text{ft}) \times (10\text{floors}) \times (0.23 \text{ Btu}/(\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}) \times (70-1)(^{\circ}\text{F})) = 5819 \text{ Btu} / \text{hr}$$

$$\dot{Q}_{\text{brick sides}} = 2 \times \left(\frac{26+18}{12} \frac{\text{ft}}{\text{floor}}\right) \times (10\text{ft}) \times (10\text{floors}) \times (0.22 \text{ Btu}/(\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}) \times (70-1)(^{\circ}\text{F})) = 11132 \text{ Btu} / \text{hr}$$

$$\dot{Q}_{\text{gypsum side}} = \left(\frac{26+18}{12} \frac{\text{ft}}{\text{floor}}\right) \times (10\text{ft}) \times (10\text{floors}) \times (0.15 \text{ Btu}/(\text{hr}\cdot\text{ft}^2\cdot^{\circ}\text{F}) \times (70-1)(^{\circ}\text{F})) = 3795 \text{ Btu} / \text{hr}$$

The total heat loss through walls

$$\dot{Q}_{\text{wall}} = 5919 + 11132 + 3795 = 20746 \text{ Btu/hr}$$

And the total heat loss

$$\dot{Q}_{\text{wall}} + \dot{Q}_{\text{infiltration}} = 20746 + 1119.3 = 21865 \text{ Btu/hr}$$

$$\text{or} \quad = 524760 \text{ Btu/day} = 154 \text{ kW}\cdot\text{hr/day}$$

Sample calculation is presented for 10, 20 and 40 story building for the cases of open and closed trap in both winter and summer. The results show the sources of losses with the saving by using *The Bennett* garbage chute.

	Winter - opened trap	Winter - <i>Bennett</i>	Summer - opened trap	Summer - <i>Bennett</i>
10 floors Building				
All walls losses (Btu/hr)	21,865	17,598	2,765	2,371
Losses from Infiltration (Btu/hr)	1,119.3	1,119.3	1,389	1,389
Total (Btu/hr)	22,984	18,717	4,154	3,760
Heat Loss per day (Btu)	551,623	449,208	99,696	90,240
Saving		18.5%		9.5%
20 floors Building				
All walls losses (Btu/hr)	42,438	35,147	5,504	4,740
Losses from Infiltration (Btu/hr)	2,594	2,593	2,779	2,779
Total (Btu/hr)	45,032	37,741	8,282	7,519
Heat Loss per day (Btu)	1,080,768	905,784	198,768	180,456
Saving		16.2%		9.2%
40 floors Building				
All walls losses (Btu/hr)	85,114	70,114	10,864	9,472
Losses from Infiltration (Btu/hr)	5,187	5,187	5,557	5,557
Total (Btu/hr)	90,302	75,302	16,421	15030
Heat Loss per day (Btu)	2,167,248	1,807,248	394,104	360,720
Saving		16.6%		8.5%

$$\text{Saving} = \frac{[Q_{\text{trap open}} - Q_{\text{trap closed}}]}{Q_{\text{trap open}}} \times 100$$

Table 3.1 Sample Calculations for different buildings.

Concluding Remarks

- The maximum energy saving with *The Bennett* will be between 18% winter time and about 10% in summer time.
- The heat loss calculation presented do not include secondary heat loss sources such as:
 - o Infiltration through elevator well,
 - o Infiltration through the frequent opening of the building front and side doors,
 - o Infiltration through walls, windows, doors, cracks or other building components,
 - o The chute door leakage due to loose shut,
 - o The influence of exhaust contractions has not been included. The garbage room (basement) is assumed closed, but not air-tight (i.e. updraft air is drawn from this room).
 - o The chute trap assumed to be closed all the time (for the case when *The Bennett* trap is installed), since the opening time is relatively short to the floor chute door.
- The amount of heat lost through the garbage chute depends on the temperature inside the building, the amount of conditioned air supplied to the building, the number of people in the building and the frequency the garbage chute doors opened.
- For open trap operation, the heat loss through the chute increases directly with the wind speed. For closed trap door operation, the effect of wind speed is mitigated since the airflow through the chute is blocked during most of the day.
- The present estimates consider only the heat losses through the chute. Estimates do not include losses through the rest of the building envelope.

Future Work

- A computerized Excel sheet will be prepared to calculate the losses with changing the different variables. The Excel sheet will have input of:
 - o Number of floors.
 - o Number of apartments per floor.
 - o Number of people per apartment.
 - o Outdoor and indoor conditions.
 - o Frequency of the chute door opening.
 - o Type of the chute vent.

The output will be:

- o Heat loss without the installation of *The Bennett* trap.
- o Heat loss with *The Bennett* trap installed.
- o The power saving with the use of *The Bennett* trap.
- o The energy saving cost.

References

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