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H. J. Heinz Distribution Facility

Pittsburgh, PA

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ASHRAE Standard 62-2001

Executive Summary

The American Society of Heating, Refrigeration and Air-Conditioning Engineers sets standards that heating, ventilation, and air-conditioning engineers should adhere to. One such standard, number 62, is one that every engineer utilizes as the first step in designing a mechanical system to verify that it will be suitable for a building and its occupants. ASHRAE Standard 62 states that every building needs a certain percentage of fresh outdoor air to be supplied into the building by whatever means possible to make sure that the occupants are not breathing the same stagnant air all the time. To achieve this, ASHRAE sets a system for determining the number of "air changes per hour" that a building needs, and how much outdoor air should be included in those air changes.

The H. J. Heinz distribution facility in Pittsburgh is a 150,000 ft^2 warehouse facility that also has three offices, two break rooms, two sets of rest rooms, two janitorial closets, and a room encasing the conveyor system into the warehouse from the factory. The warehouse covers ninety-two percent of the entire facility, and is mostly open space for storage, but there is still a requirement for fresh-air ventilation. For air treatment, the facility consists of six heat pumps (at 70 CFM each) in the offices and break rooms, and two centrifugal supply fans (at 1,900 CFM each) that supply air to the conveyor enclosure.

Applying the above information, the given and the required quantities of ventilation air and adding an estimated amount of outdoor air infiltration, it was determined that the H. J. Heinz distribution facility indeed does not meet the requirements for ASHRAE Standard 62-2001.

Appraisal of ASHRAE Standard 62-2001

The required amount of outdoor air according to Standard 62 per space is as follows:

Space	Floor Area (ft^2)	Occupants	CFM / ft^2	CFM / person	Total CFM
Conveyor	9,535	2	0.05		477
Warehouse	138,980	20	0.05		6,949
Break 107	152	3		60	180
Men 105	58	0			20
Women 104	58	0			20
Janitor 106	32	0			20
Office 108	96	1		20	20
Office 111	172	1		20	20
Office 112	172	1		20	20
Men 113	135	0			20
Women 114	135	0			20
Janitor 115	25	0			20
Break 116	416	5		60	300
Total	149,966	33			8,086

[These calculations were performed assuming the number of people in each space. The required per space was obtained from Table 2 in ASHRAE Standard 62.]

TABLE 2
OUTDOOR AIR REQUIREMENTS FOR VENTILATION* (*Continued*)
2.1 COMMERCIAL FACILITIES (offices, stores, shops, hotels, sports facilities)

Application	Estimated Maximum** Occupancy P/1000 ft^2 or 100 m^2	Outdoor Air Requirements: cfm/person	L/s·person	cfm/ft^2	L/s·m^2	Comments
Retail Stores, Sales Floors, and Show Room Floors						
Basement and street	30			0.30	1.50	
Upper floors	20			0.20	1.00	
Storage rooms	15			0.15	0.75	
Dressing rooms				0.20	1.00	
Malls and arcades	20			0.20	1.00	
Shipping and receiving	10			0.15	0.75	
Warehouses	5			0.05	0.25	
Smoking lounge	70	60	30			Normally supplied by transfer air, local mechanical exhaust; exhaust with no recirculation recommended.

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Offices						
Office space	7	20	10			Some office equip
Reception areas	60	15	8			exhaust.
Telecommunication centers and data entry areas	60	20	10			
Conference rooms	50	20	10			

Calculation of Equipment-Supplied Outdoor Air

The amount of outdoor air supplied to each room via the heat pumps and supply fans is as follows:

Space	CFM
Conveyor / Warehouse	3,800
Break Room 107	70
Men 105	0
Women 104	0
Janitor 106	0
Office 108	70
Office 111	70
Office 112	70
Men 113	0
Women 114	0
Janitor 115	0
Break Room 116	140
Total	4,220

[These numbers were obtained by assuming that the air supplied to the conveyor room can easily spread to the warehouse, and that each heat pump supplies only the room it resides in. Obviously, this would not be the case in more detailed calculations.]

Comparing the amounts of supplied and required outdoor air (per the Standard 62 Multiple Spaces Equation):

Space	Supplied CFM	Required CFM	Z = (Req. / Supplied)
Conveyor / Warehouse	3,800	7,426	1.954
Break 107	70	180	2.571
Men 105	0	20	(20)
Women 104	0	20	(20)
Janitor 106	0	20	(20)
Office 108	70	20	0.286
Office 111	70	20	0.286
Office 112	70	20	0.286
Men 113	0	20	(20)
Women 114	0	20	(20)
Janitor 115	0	20	(20)
Break 116	140	300	2.143
Total	4,220	8,086	

Determination of "Z" from Multiple Spaces Equation

The Multiple Spaces equation was obtained from ASHRAE Standard 62-2001; Section 6.1.3.1:

$$Y = X / [1 + X - Z]$$

Where the definitions of X, Y, and Z are:

$Y = V_{ot} / V_{st}$ = corrected fraction of outdoor air in system supply
$X = V_{on}/V_{st}$ = uncorrected fraction of outdoor air in system supply
$Z = V_{oc}/V_{sc}$ = fraction of outdoor air in critical space. The critical space is that space with the greatest required fraction of outdoor air in the supply to this space.

The various flow rates are as follows:

V_{ot} = corrected total outdoor air flow rate
V_{st} = total supply flow rate, i.e., the sum of all supply for all branches of the system
V_{on} = sum of outdoor air flow rates for all branches on system
V_{oc} = outdoor air flow rate required in critical spaces
V_{sc} = supply flow rate in critical space

In order for a space to comply with Standard 62, the "Z" fraction should be less than 1.0. This means that the conveyor room, the warehouse, and the two break rooms do not comply with the ASHRAE required amounts of outdoor air. Typically, when a building does comply, the space with the highest "Z" will be the critical space. That is the space that will require the largest percentage of outdoor air to be supplied to it every time that a full building volume of air is exchanged. Using this definition, each of the break rooms should be considered as the critical spaces.

Infiltration: Fallacies of ASHRAE Standard 62

When calculating the amount of air supplied to a space, Standard 62 does not consider the spread of air throughout the building after being supplied to a single space. For instance, normally air is not supplied to a bathroom, but ASHRAE does calculate its existence since the air is being exhausted from the bathroom. Obviously, air will not remain in the space in which it is supplied, and this fact needs to be observed when the total amount of ventilation air within the building is calculated. Every building has some natural ventilation through infiltration, and this infiltration must be considered in the H. J. Heinz facility because there are 16 ninety-square-foot garage doors that have cracks around them, will be opened occasionally and each will add to the amount of infiltration.

I looked at two different ways to calculate the amount of infiltration within the building. Both are good forms of calculating the amount of infiltration, but both give very rough estimates. If I had the ability to perform an air balance test, or a blow-air door test, then the estimate could be much more reliable, but obviously I don't have the ability to do either of those tests with my lack of knowledge and equipment.

Infiltration Evaluation, #1

The first "quick rule of thumb" that I used was the 5% rule (*Stein and Reynolds, 2000*). This rule states that "if the operable window area is 5% of the floor area of the room being observed, the adequate natural ventilation is assumed to be achievable."[1] Since the windows provided in the offices and break rooms are permanently sealed, the infiltration of those rooms could not be verified using this calculation. Assuming that the sixteen garage doors are considered equivalent to "operable windows", then the infiltration into the warehouse space can be verified using this rule. Each door is 9 feet by 10 feet, and that gives 1,440 square feet of "open" space.

Floor	140,000 ft^2	140,000 x 0.05 = 70,000 ft^2 open space required.
Doors	90 ft^2 each	90 x 16 doors = 1,440 ft^2 open space available.

By calculating the square footage of open space that allows infiltration (1,440 ft^2) per 5 percent of the space that requires infiltration (70,000 ft^2) then the number of air changes per hour (ACH) are determined.

$$1,440 / 70,000 = 0.0206 \text{ ACH}$$

A typical range of ACH that is considered acceptable is 0.5 to 2.0 (McQuiston, et al.).[2] Occasionally a modern office building will be as low as 0.1 ACH, but a value that low is not recommended.[2] According to this standard, the 0.0206 ACH of infiltration produced at the Heinz facility is far from adequate.

[1] *Mechanical and Electrical Equipment for Buildings, 9th edition*; Benjamin Stein and John S. Reynolds. John Wiley & Sons, Inc; 2000
[2] *Heating, Ventilating, and Air Conditioning, Analysis and Design, 5th edition*; Faye C. McQuiston, Jerald D. Parker, Jeffery D. Spitler. John Wiley & Sons, Inc; 2000

Infiltration Evaluation, #2

The second model of calculating the quantity of infiltration into the building is the Lawrence-Berkeley National Laboratory method (Fundamentals, 2001)[3]. This method uses the effective leakage area around openings in the building, and uses known average values for wind speed and temperature in the location of the building. The formula that calculates the rate of infiltration as determined from chapter 26 in the ASHRAE Handbook of Fundamentals is:

$$Q = A_L \sqrt{C_s \Delta t + C_w U^2}$$

Where:

Q = airflow rate, m^3/s
A_L = effective air leakage area, cm^2
C_s = stack coefficient, $(L/s)^2/(cm^4 \cdot K)$
Δt = average indoor-outdoor temperature difference for time interval of calculation, K
C_w = wind coefficient, $(L/s)^2/[cm^4 \cdot (m/s)^2]$
U = average wind speed measured at local

Table 7 Basic Model Stack Coefficient C_s

	House Height (Stories)		
	One	Two	Three
Stack coefficient	0.000 145	0.000 290	0.000 435

Table 8 Local Shelter Classes

Shelter Class	Description
1	No obstructions or local shielding
2	Typical shelter for an isolated rural house
3	Typical shelter caused by other buildings across the street from the building under study
4	Typical shelter for urban buildings on larger lots where sheltering obstacles are more than one building height away
5	Typical shelter produced by buildings or other structures that are immediately adjacent (closer than one house height): e.g., neighboring houses on the same side of the street, trees, bushes, etc.

Table 9 Basic Model Wind Coefficient C_w

Shelter Class	House Height (Stories)		
	One	Two	Three
1	0.000 319	0.000 420	0.000 494
2	0.000 246	0.000 325	0.000 382
3	0.000 174	0.000 231	0.000 271
4	0.000 104	0.000 137	0.000 161
5	0.000 032	0.000 042	0.000 049

[3] *ASHRAE Handbook of Fundamentals*; The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc; 2001

Determination of factors

Using the fact that the building height is 33 feet, a "house height" of three stories was chosen and stack coefficient (C_s) of 0.000435 was obtained. Since there is a hill on one side of the building, trees on the other, and the factory on a third, a "shelter class" of 3 was picked. Using these numbers, determination of a wind coefficient was found to be 0.000271.

For the effective leakage area, a full one inch gap was assumed around each garage door. This gave approximately 500 in^2 (3,226 cm^2) of leakage area.

An indoor temperature of 65°F (291°K) was assumed.

An outdoor temperature of 23°F (268°K) was obtained from the ASHRAE handbook, Table 1A in chapter 27. Also, an extreme wind speed of 19 mph (8.5 m/s) was found in the same table.

Table 1A Heating and Wind Design Conditions—United States

Station	WMO#	Lat.	Long.	Elev., ft	StdP, psia	Dates	Heating Dry Bulb 99.6%	Heating Dry Bulb 99%	Extreme Wind Speed, mph 1%	2.5%	5%	Coldest Month 0.4% WS	0.4% MDB	1% WS	1% MDB
1a	1b	1c	1d	1e	1f	1g	2a	2b	3a	3b	3c	4a	4b	4c	4d
Eugene	726930	44.12	123.22	374	14.498	6193	21	26	20	18	16	22	46	19	45
Hillsboro	726986	45.53	122.95	203	14.588	8293	19	24	19	17	15	23	26	19	34
PENNSYLVANIA															
Allentown	725170	40.65	75.43	384	14.493	6193	5	10	27	23	21	28	26	25	24
Altoona	725126	40.30	78.32	1503	13.915	8293	5	10	20	18	17	23	20	20	22
Bradford	725266	41.80	78.63	2142	13.593	6193	−6	−1	19	18	16	22	22	19	21
Du Bois	725125	41.18	78.90	1818	13.756	8293	0	5	21	19	17	23	20	21	20
Erie	725260	42.08	80.18	738	14.308	6193	2	7	27	24	22	29	28	26	28
Harrisburg	725115	40.20	76.77	308	14.532	6193	9	13	22	20	18	24	29	22	29
Philadelphia, Intl Airport	724080	39.88	75.25	30	14.680	6193	11	15	24	21	19	26	31	23	30
Philadelphia, Northeast A	724085	40.08	75.02	121	14.631	8293	11	15	21	19	17	22	30	19	29
Philadelphia, Willow Gr NAS	724086	40.20	75.15	361	14.505	8293	10	14	18	15	13	19	30	16	30
Pittsburgh, Allegheny Co. A	725205	40.35	79.93	1253	14.042	8293	4	11	21	19	17	23	24	21	24

Using the above factors, the infiltration rate was found to be 70,544 ft^3/hr (1,176 CFM = 555 L/s).

$$Q = L\,(C_s{*}\Delta T + C_w{*}V^2)^{1/2}$$

Q =	Infiltration Rate (L/s)	??
L =	Effective Leakage Area (cm^2)	3,226
C_s =	Stack Coefficient ($L^{2}{*}s^{-2}{*}cm^{-4}{*}K^{-1}$)	0.000435
ΔT =	Indoor-Outdoor Temperature Difference (K)	23
C_w =	Wind Coefficient ($L^{2}{*}s^{-2}{*}cm^{-4}{*}K^{-1}$)	0.000271
V =	Average Wind Speed (m/s)	8.5

Q =	554.88	(L/s)		
Q =	70,543	(ft^3/hr) =	1,176	CFM
ACH =	0.0202			

The number of air changes was calculated by dividing the infiltration flow rate (70,543 ft^3/hr) by the volume of the facility (3,500,000 ft^3) and found there are 0.0202 air changes via infiltration.

This value of air changes (0.0202) is very close (1.9% variation) to the number determined in the first method of 0.0206 ACH. This small variation says that both techniques that supply a rough estimate give a very similar estimate.

No matter which "quick estimate" method is applied, a very small amount of infiltration is concluded. According to McQuiston et al. a minimum value of 0.1 should be attained, and infiltration is simply not going to help accomplish this feat in the situation of the H. J. Heinz distribution facility. Assuming that every CFM of outside air (3,800 CFM; 0.065 ACH) that is supplied into the conveyor section actually enters the warehouse, and that air is added to the amount of infiltration (1,176 CFM; 0.0202 ACH), it is still not a sufficient amount of ventilation. 0.0852 air changes per hour is still much less than the minimum of 0.1 ACH suggested by McQuiston et. al.