

$$\dot{V}_{bz} = R_p \cdot P_z + R_a \cdot A_z$$

$$SHR = \frac{\dot{Q}_{sens}}{\dot{Q}_{sens} + \dot{Q}_{lat}}$$

$$\dot{m}_{a1} + \dot{m}_{a2} = \dot{m}_{a3}$$

$$W = \frac{w_w}{w_a} = \frac{0.622 P_w}{P_T - P_w}$$

$$\text{Latent (kJ/kg)} = W (2500 + 1.86t)$$

$$K_{cond} = \sum_k U_k A_k = U_{glaz} A_{glaz} + U_{wall} A_{wall} + U_{roof} A_{roof}$$

$$\dot{Q}_{sens,tot} = \dot{Q}_{cond} + \dot{Q}_{sens,air} = (K_{cond} + \rho c_p \dot{V})(T_i - T_o)$$

$$\dot{Q}_{gain} = \dot{Q}_{sol} + \dot{Q}_{lit} + \dot{Q}_{equ} + \dot{Q}_{occ}$$

$$\dot{Q}_{sens} = \dot{Q}_{cond} + \dot{Q}_{sens,air} + \dot{Q}_{floor} - \dot{Q}_{gain} \mp \dot{Q}_{stor}$$

$$\dot{Q}_{lat,air} = \dot{V} \rho h_{fg} (W_o - W_i) \text{ where: } \rho \cdot h_{fg} = 3010 \text{ W/(L/s) at standard conditions}$$

$$C_i = C_o + \frac{\dot{V}_{pol}}{\dot{V}_o}$$

$$E_v = \frac{1-S}{1-RS}$$

$$\dot{m}_{a1} h_1 + \dot{m}_{a2} h_2 = \dot{m}_{a3} h_3$$

$$P_w = P_{sat} \times RH$$

$$\text{Sensible (kJ/kg)} = 1.005t$$

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ASHRAE Standard 62.1-2016 Ventilation for Acceptable Indoor Air Quality

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone

(Table 6.2.2.1 shall be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			
	cfm/ person	L/s· person	cfm/ft ²	L/s·m ²		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		Air Class
						#/1000 ft ² or #/100 m ²	cfm/ person	L/s· person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3	H	65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	H	150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3	H	35	12	5.9	1
Multiuse assembly	7.5	3.8	0.06	0.3	H	100	8	4.1	1
Food and Beverage Service									
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1	2
Cafeteria/fast-food dining	7.5	3.8	0.18	0.9		100	9	4.7	2
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100	9	4.7	2
Kitchen (cooking)	7.5	3.8	0.12	0.6		20	14	7.0	2

TABLE 6.2.2.2 Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level (See Note 6)	1.0
Floor supply of cool air and ceiling return, provided that the vertical throw is greater than 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) or more above the floor	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification, or underfloor air distribution systems where the vertical throw is less than or equal to 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust, return, or both.	0.8
Makeup supply drawn in near to the exhaust, return, or both locations.	0.5

NOTES:

1. "Cool air" is air cooler than space temperature.
2. "Warm air" is air warmer than space temperature.
3. "Ceiling supply" includes any point above the breathing zone.
4. "Floor supply" includes any point below the breathing zone.
5. As an alternative to using the above values, E_z may be regarded as equal to air-change effectiveness determined in accordance with ASHRAE Standard 129¹⁶ for air distribution configurations except unidirectional flow.
6. For lower velocity supply air, $E_z = 0.8$.

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ASHRAE Fundamentals

TABLE 7.6

Nominal Heat Gain Values from Occupants Assuming a Mix of Men and Women

Activity	Total		Sensible		Latent		Radiant to Sensible ^a
	Btu/h	W	Btu/h	W	Btu/h	W	
Seated at rest	330	95	225	65	105	30	27–60
Seated, light office work	400	115	245	70	155	45	27–60
Standing or walking slowly	450	130	250	75	200	55	38–58
Light physical work	750	220	275	80	475	140	35–49
Heavy physical work	1450	425	580	170	870	255	19–54

^a The range corresponds to recommended space air velocities (from high to low).

Hutcheon and Handegord – Building Science for a Cold Climate

TABLE 5.1

**Water-Vapour Pressures at Saturation at Various Temperatures over Plane
Surfaces of Pure Water and Pure Ice**

Pressure, Pa			Pressure, Pa			Temp., °C	Press., kPa	Temp., °C	Press., kPa
Temp., °C	Over ice	Over water	Temp., °C	Over ice	Over water				
−50	3.935	6.409	−22	85.02	105.4	5	0.8719	33	5.031
−49	4.449	7.124	−21	93.70	115.0	6	0.9347	34	5.320
−48	5.026	7.975	−20	103.2	125.4	7	1.001	35	5.624
−47	5.671	8.918	−19	113.5	136.6	8	1.072	36	5.942
−46	6.393	9.961	−18	124.8	148.8	9	1.147	37	6.276
−45	7.198	11.11	−17	137.1	161.9	10	1.227	38	6.626
−44	8.097	12.39	−16	150.6	176.0	11	1.312	39	6.993
−43	9.098	13.79	−15	165.2	191.2	12	1.402	40	7.378
−42	10.21	15.34	−14	181.1	207.6	13	1.497	41	7.780
−41	11.45	17.04	−13	198.4	225.2	14	1.598	42	8.202
−40	12.83	18.91	−12	217.2	244.1	15	1.704	43	8.642
−39	14.36	20.97	−11	237.6	264.4	16	1.817	44	9.103
−38	16.06	23.23	−10	259.7	286.3	17	1.937	45	9.586
−37	17.94	25.71	−9	283.7	309.7	18	2.063	46	10.09
−36	20.02	28.42	−8	309.7	334.8	19	2.196	47	10.62
−35	22.33	31.39	−7	337.9	361.8	20	2.337	48	11.17
−34	24.88	34.63	−6	368.5	390.6	21	2.486	49	11.74
−33	27.69	38.18	−5	401.5	421.5	22	2.643	50	12.33
−32	30.79	42.05	−4	437.2	454.5	23	2.809	51	12.96
−31	34.21	46.28	−3	475.7	489.8	24	2.983	52	13.61
−30	37.98	50.88	−2	517.3	527.5	25	3.167	53	14.29
−29	42.13	55.89	−1	562.3	567.8	26	3.361	54	15.00
−28	46.69	61.39	0	610.8	610.8	27	3.565	55	15.74
−27	51.70	67.27	Triple point of water			28	3.780	56	16.51
−26	57.20	73.71	1	—	656.6	29	4.006	57	17.31
−25	63.23	80.70	2	—	705.5	30	4.243	58	19.15
−24	69.85	88.27	3	—	757.5	31	4.493	59	19.02
−23	77.09	96.49	4	—	812.9	32	4.755	60	19.92

