

Engineering Equations and Conversion Factors

KJWW Education Committee

1 Btu = Heat 1# H <sub>2</sub> O 1°F	Latent Heat (H <sub>2</sub> O) = 1,000 Btu/#	°F = °C (9/5) + 32
1 # steam ≈ 1,000 Btu	Fusion Heat (H <sub>2</sub> O) = 144 Btu/#	1" Mercury (Hg) = 1.133 ft H <sub>2</sub> O = 13.6" H <sub>2</sub> O
1 boiler HP = 33,475 Btu/hr	KVA (3φ) = $V \times I \times 1.73$ 1,000	1 acre = 43,560 ft <sup>2</sup>
1 ft <sup>2</sup> radiation (1 EDR) = 240 Btu/hr	KW (3φ) = $V \times I \times 1.73 \times Pf$ 1,000	1 ft <sup>3</sup> /sec = 449 GPM
500 #/hr (steam condensate) = 1 GPM	1 KW elect = 3,415 Btu/hr	1 psi = 2.31 ft H <sub>2</sub> O = 27.72" H <sub>2</sub> O
1 ft <sup>3</sup> nat gas ≈ 1,000 Btu	0.75 KW elect = 1 HP/eff	1 pound = 7,000 grains
1 gal #2 oil = 138,000 Btu	1 ft <sup>3</sup> of H <sub>2</sub> O = 62.4 #	
1 gal propane = 92,000 Btu	1 gal of H <sub>2</sub> O = 8.34 #	
	1 ft <sup>3</sup> of H <sub>2</sub> O = 7.48 gal	
1 therm = 100,000 Btu ≈ 100 cf nat gas = 0.72 gal #2 oil	1 ton = 12,000 Btuh (1 ton of ice at 32 Deg F melting in one day)	1 Atmosphere = 29.92" Hg = 14.7 Psi = 34 ft H <sub>2</sub> O

Cv is the flow in GPM through a device with a pressure difference of 1 psi. Kv is the metric equivalent.

$$GPM = C_v \times \sqrt{\Delta P}$$

$$K_v = C_v / 1.16$$

Steam Cv relates flow to outlet pressure and pressure drop through valve

$$Lb/hr \text{ steam flow} = C_v \times 3 \times \sqrt{(\Delta P \times \text{outlet pressure in psia})} \text{ (source Belimo)}$$

Air Changes/Hour: ACH = Cfm x 60/(Room Volume)

Velocity pressure of air:

$$("H_2O) = (fpm/4005)^2$$

$$fpm = 4005 \times \sqrt{("H_2O)}$$

Rules of Thumb:

0.8 - 1.5 Cfm/ft<sup>2</sup> – Cooling office/ school/ warehouse/ hospital can vary a lot

300 - 400 Cfm/Ton – Cooling again can vary a lot

25 - 45 Btu/ft<sup>2</sup> - Heating

% floor space needed for mech room

Refrigeration Equations

EER	= 12/(KW/Ton)
KW/Ton	= 12/EER
COP (cooling)	= Output/Input
EER	= COP x 3.415
COP	= EER/3.415
KW/Ton	= 3.513/COP
COP	= 3.513/(KW/Ton)

Heating or Cooling with Water:

Heating:

Btu/hr = GPM x 500 x ΔT

Cooling:

1 ton (C.W.) = GPM x 500 x ΔT/12,000

Traditional Flow Rates:

- Chilled H<sub>2</sub>O = 2.4 GPM/ton (10°ΔT could also be 12, 14, 16 °ΔT)
- Heating H<sub>2</sub>O = 1.0 GPM/10,000Btu (20°ΔT could also be 30,40 °ΔT)
- Cond. H<sub>2</sub>O = 3.0 GPM/ton (10°ΔT) could also be 12, 14 °ΔT)
- Cond. H<sub>2</sub>O (absorp) = 5.0 GPM/ton (≈ 17°ΔT)

To Cool Air:

Total Btuh = Cfm x 4.5 x Δenthalpy  
(The Δenthalpy must come from the psych chart)

To Heat Air:

Btuh/hr = Cfm x 1.08 x ΔT°F (1.1 for non-dry air)

To Humidify Air:

#/hr H<sub>2</sub>O = CFM x 4.5 x ΔGrains / 7,000

Pump Horsepower:

(Water) HP = GPM x ft Head x .0002525 / eff.  
eff varies from 60% to 85% above 5 hp pumps.

Fan Horsepower:

HP = CFM x static press (“H<sub>2</sub>O) x .000157 / eff.  
eff varies from 55% to 75% above 5 hp fans.  
Fans add ½°F to air temp for each 1" static pressure.

Belt losses = 30% @ 1/4 HP; 20% @ 1/2 HP; 10% @ 3 HP; 5% @ 20 HP

Pipe Sizing:

Chilled water and Heating water:

(at 4'/100' ΔP)	Copper Pipe		Steel Pipe	
	1/2" =	1.3 GPM	2-1/2" =	75 GPM
	3/4" =	3.5 GPM	3" =	140 GPM
	1" =	7.5 GPM	4" =	270 GPM
	1 1/4" =	13 GPM	6" =	850 GPM
	1 1/2" =	20 GPM	8" =	1700 GPM
	2" =	45 GPM	10" =	2500 GPM **

\*\* = limited to 10 fps.

Maximum Air Velocities Through Equipment: (fpm)

Coils		Louvers				Filters
Chilled Water	Heating Water & Steam	Outside Air		Exhaust Air		
		Face Area (use?)	Free Area	Face Area (use?)	Free Area	
450?	Delta P?	450	900	650	1200	350

**Pump Affinity Laws (open systems!)**

Flow<sub>2</sub> = RPM<sub>2</sub> = D<sub>2</sub>  
 Flow<sub>1</sub> = RPM<sub>1</sub> = D<sub>1</sub>  
 Press.<sub>2</sub> = (RPM<sub>2</sub>)<sup>2</sup> = (D<sub>2</sub>)<sup>2</sup>  
 Press.<sub>1</sub> = (RPM<sub>1</sub>)<sup>2</sup> = (D<sub>1</sub>)<sup>2</sup>  
 BHP<sub>2</sub> = (RPM<sub>2</sub>)<sup>3</sup> = (D<sub>2</sub>)<sup>3</sup>  
 BHP<sub>1</sub> = (RPM<sub>1</sub>)<sup>3</sup> = (D<sub>1</sub>)<sup>3</sup>

**Fan Affinity Laws (no variable pressure drop)**

Flow<sub>2</sub> = RPM<sub>2</sub> = (D<sub>2</sub>)<sup>3</sup>  
 Flow<sub>1</sub> = RPM<sub>1</sub> = (D<sub>1</sub>)<sup>3</sup>  
 Press.<sub>2</sub> = (RPM<sub>2</sub>)<sup>2</sup> = (D<sub>2</sub>)<sup>2</sup>  
 Press.<sub>1</sub> = (RPM<sub>1</sub>)<sup>2</sup> = (D<sub>1</sub>)<sup>2</sup>  
 BHP<sub>2</sub> = (RPM<sub>2</sub>)<sup>3</sup> = (D<sub>2</sub>)<sup>5</sup>  
 BHP<sub>1</sub> = (RPM<sub>1</sub>)<sup>3</sup> = (D<sub>1</sub>)<sup>5</sup>

**Plumbing Water Pipe Sizing:**

H = Hot  
C = Cold

[ILL PC = Illinois Plumbing Code](#)  
IPC = International Plumbing Code

UPC = Uniform Plumbing Code  
[WAC = Wisconsin Administrative Code](#)

**FIXTURE UNITS**

Item	Trap (in.)	2004 ILL PC			2006 IPC			2006 UPC			2007 WAC		
		SFU		DFU	SFU		DF U	SFU		DF U	SFU		DF U
		C	H		C	H		C	H		C	H	
Dishwasher (Residential)	1-1/2"	-	1	a	-	1.4	2	-	1.5	2	-	1	2
Drinking Fountain	1-1/4"	0.25	-	0.5	0.25	-	0.5	0.5	-	0.5	0.25	-	0.5
Mop Basin	3"	2.25	2.25	3	2.25	2.25	3	2.25	2.25	3	2	2	3
<b>BATHTUBS:</b>													
Bathtub (Public)	1-1/2"	3	3	3	3	3	2	3	3	2	2	2	2
Bathtub (Private)	1-1/2"	1.5	1.5	3	1	1	2	3	3	2	1.5	1.5	2
<b>CLOTHES WASHER:</b>													
Automatic-Small (Public)	-	2.25	2.25	3	2.25	2.25	3	3	3	3	2	2	4
Automatic-Large (Public)	-	3	3	3	3	3	3	-	-	-	-	-	-
Automatic-Small (Private)	-	1.5	1.5	3	1	1	2	3	3	3	1	1	3
<b>FLOOR DRAINS</b>	2"	-	-	3	-	-	3	-	-	4	-	-	2
	3"	-	-	5	-	-	5	-	-	6	-	-	3
	4"	-	-	6	-	-	6	-	-	8	-	-	4
	Larger than 4"	-	-	-	-	-	-	-	-	-	-	-	4
<b>HOSE BIBBS:</b>													
1/2" Diameter	-	-	-	-	-	-	-	2.5	-	-	3	-	-
3/4" Diameter	-	-	-	-	-	-	-	-	-	-	4	-	-
<b>LAVATORIES:</b>													
Lavatory (Public)	1-1/4"	1.5	1.5	2	1.5	1.5	1	0.75	0.75	1	0.5	0.5	1
Lavatory (Private)	1-1/4"	0.75	0.75	1	0.5	0.5	1	0.75	0.75	1	0.5	0.5	1
<b>SHOWERS:</b>													
Shower Stall (Public)	2"	-	-	-	3	3	2	1.5	1.5	2	2	2	2
Shower Stall (Private)	2"	1.5	1.5	3	1	1	2	1.5	1.5	2	1	1	2
Shower (group) per head		3	3	3	-	-	-	-	-	1	2	2	2
<b>SINKS:</b>													
Kitchen (Domestic)	1-1/2"	1.5	1.5	2	1	1	2	1.5	1.5	2	1	1	2
Service	3"	2.25	2.25	3	2.25	2.25	3	2.25	2.25	3	2	2	3
Clinical	3"	a	a	8	-	-	-	8	3	6	7	2	6
Sink	1-1/2"	3	3	2	3	3	2	-	-	-	2	2	2
Exam	1-1/2"	0.75	0.75	2	1	1	2	1.5	1.5	2	0.5	0.5	1
<b>URINALS:</b>													

Syphon Jet	2"	10	-	8	10	-	4	4	-	2	4	-	2
Washdown	2"	5	-	3	5	-	2	4	-	2	2	-	2
<b>WATER CLOSETS:</b>													
WC Tank (Public)	3"	5	-	4	5	-	4	2.5	-	4	3	-	6
WC Tank (Private)	3"	3	-	4	2.2	-	4	2.5	-	3	2	-	4
WC Valve (Public)	3"	10	-	8	10	-	4	5	-	4	6.5	-	6
WC Valve (Private)	3"	6	-	8	6	-	3	5	-	3	6	-	4

a = No value given in code, use values from similar fixtures.

**Fixture Unit Equivalents:**

Fixture Drain or Trap Size	DFU			
	ILL '04	IPC '06	UPC '06	WAC '07
Smaller than 1-1/4"	1	-	-	-
1-1/4"	1	1	1	1
1-1/2"	2	2	3	2
2"	3	3	4	3
2-1/2"	4	4	-	-
3"	5	5	6	4
4"	6	6	8	6
Larger than 4"	-	-	-	8

**\*\* SIZING SANITARY AND VENT LINES \*\***  
**REFER TO CODES FOR SIZING**

**Building Drain Sizing:**

SIZE	Slope / Foot															
	ILL PC '04				IPC '06				UPC '06				WAC '07			
	1/16"	1/8"	1/4"	1/2"	1/16"	1/8"	1/4"	1/2"	1/16"	1/8"	1/4"	1/16"	1/8"	1/4"	1/2"	
1-1/4"	-	-	-	-	-	-	1	1	-	0.8	1	-	-	-	-	
1-1/2"	-	-	-	-	-	-	3	3	-	0.8	1	-	-	-	-	
2"	-	-	-	-	-	-	21	26	-	6	8	-	-	6	9	
2-1/2"	-	-	-	-	-	-	24	31	-	11	14	-	-	-	-	
3"	-	-	-	-	-	36	42	50	-	28	35	-	36	42	50	
4"	-	180	216	250	-	180	216	250	-	173	216	-	180	216	250	
5"	-	390	480	575	-	390	480	575	-	342	428	-	390	480	575	
6"	-	700	840	1,000	-	700	840	1,000	-	576	720	-	700	840	1,000	
8"	1,400	1,600	1,920	2,300	1,400	1,600	1,920	2,300	1,950	2,800	3,900	1,400	1,600	1,920	2,300	
10"	2,500	2,900	3,500	4,200	2,500	2,900	3,500	4,200	3,400	4,900	6,800	2,500	2,900	3,500	4,200	
12"	3,900	4,600	5,600	6,700	3,900	4,600	5,600	6,700	5,600	8,000	11,200	3,900	4,600	5,600	6,700	
15"	7,000	8,300	10,000	12,000	7,000	8,300	10,000	12,000	-	-	-	7,000	8,300	10,000	12,000	

**Fixture Units VS. GPM:**

FV = Flush Valve

NFV = Non-Flush Valve

SFU	FV GPM	NFV GPM
1	-	1
2	-	2
3	-	3
4	10	4
5	15	4.5
6	18	5
7	21	6
8	24	6.5
9	26	7
10	27	8
20	35	14

SFU	FV GPM	NFV GPM
30	40	20
40	46	24
50	51	28
60	54	32
70	58	35
80	62	38
90	65	41
100	68	42
120	73	48
140	78	53
160	83	57

SFU	FV GPM	NFV GPM
180	87	61
200	92	65
250	101	75
300	110	85
400	126	105
500	142	125
600	157	143
700	170	161
800	183	178
900	197	195
100	208	208

SFU	FV GPM	NFV GPM
1250	240	240
1500	267	267
1750	294	294
2000	321	321
2250	348	348
2500	375	375
2750	402	402
3000	432	432
4000	525	525
5000	593	593
10,000	769	769

**Storm Drainage Sizing:**

Note: Minimum velocity at design is to be 2 ft/sec to carry debris in the line.

SIZE	HORIZONTAL			VERTICAL	
	2006 IPC & 2006 UPC			2006 IPC	2006 UPC
	1/8" (1%)	1/4" (2%)	1/2" (4%)		
2"	--	--	--	720	544
3"	822	1,160	1,640	2,200	1,610
4"	1,880	2,650	3,760	4,600	3,460
5"	3,340	4,720	6,680	8,650	6,280
6"	5,350	7,550	10,700	13,500	10,200
8"	11,500	16,300	23,000	29,000	22,000
10"	20,700	29,200	41,400	--	--
12"	33,300	47,000	66,600	--	--
15"	59,500	84,000	119,000	--	--

Horizontally projected roof area (ft<sup>2</sup>) (Based on 4"/hour rainfall)

**2007 WAC, Comm. 82.36 (Cast Iron)**

SIZE	HORIZONTAL			VERTICAL
	1/8" (1%)	1/4" (2%)	1/2" (4%)	
3"	40	60	80	80
4"	90	130	180	173
5"	170	230	330	315
6"	270	380	540	516
8"	590	830	1,170	1,118
10"	1,090	1,540	2,170	2,068
12"	1,740	2,490	3,490	3,318
15"	3,270	4,620	6,530	6,217

Capacities listed are in GPM. Refer to WAC for sizing values of other materials.

Runoff from land surfaces:

Q=CIA where

(Q=Cfs; I = "/hr; A=Acres)

C for surfaces:

Roofs/Parking

C = 1.0

Rolling lawns

C = 0.5

Timberland

C = 0.4

Cornfield

C = 0.2

Conversions:

GPM = ft<sup>2</sup> x 0.041

26 ft<sup>2</sup> = 1 GPM @ 4"/hr

**Plumbing Water Pipe Sizing:**

**FIXTURE UNITS vs. PIPE SIZE**

**2006 IPC / 2006 UPC (Type L Copper)**

SIZE	5 PSI/100		4 PSI/100		3 PSI/100		2 PSI/100		1 PSI/100		0.5 PSI/100	
	NFV	FV	NFV	FV	NFV	FV	NFV	FV	NFV	FV	NFV	FV
1/2"	2	--	2	--	2	--	1	--	--	--	--	--
3/4"	7	--	6	--	4	--	3	--	2	--	2	--
1"	18	--	15	--	10	--	8	--	4	--	3	--
1-1/4"	35	4	30	--	27	--	18	--	9	--	7	--
1-1/2"	72	21	58	15	46	10	34	3	20	--	10	--
2"	250	132	218	102	152	60	102	35	54	12	27	--
2-1/2"	650	550	480	360	380	250	280	148	138	52	68	20
3"	1280	1280	1030	1030	820	780	570	480	330	200	190	90
4"	--	--	2630	2630	2050	2050	1550	1550	840	820	480	360
6"	--	--	--	--	--	--	--	--	--	--	2730	2730

This table was assembled using data from graphs in the 2006 IPC - Appendix E (pg 129) and the 2003 UPC - Appendix A Chart A-4 (pg 249).

**2007 WAC, Comm. 82.40 (Type L Copper)**

SIZE	5 PSI/100		4 PSI/100		3 PSI/100		2 PSI/100		1 PSI/100		0.5 PSI/100	
	NFV	FV	NFV	FV	NFV	FV	NFV	FV	NFV	FV	NFV	FV
1/2"	2	--	2	--	2	--	1	--	1	--	0.5	--
3/4"	8	--	7	--	6	--	4	--	2	--	2	--
1"	20	4	16	4	14	4	10	--	6	--	4	--
1-1/4"	40	8	33	7	27	6	20	4	13	4	9	--
1-1/2"	80	26	66	18	52	12	37	7	23	5	15	4
2"	260	136	225	108	175	75	120	44	63	17	37	7
2-1/2"	--	--	469	356	410	283	305	175	170	72	86	30
3"	--	--	--	--	752	698	566	468	345	211	200	90
4"	--	--	--	--	1792	1792	1694	1694	923	909	561	462

This table is to be used when sizing piping in Wisconsin.

**2004 ILL (Appendix A)**

SIZE	5 PSI/100		4 PSI/100		3 PSI/100		2 PSI/100		1 PSI/100		0.5 PSI/100	
	NFV	FV	NFV	FV	NFV	FV	NFV	FV	NFV	FV	NFV	FV
1/2"	--	--	2	--	--	--	--	--	--	--	--	--
3/4"	--	--	--	--	--	--	--	--	--	--	--	--
1"	--	--	--	--	--	--	--	--	--	--	--	--
1-1/4"	--	--	--	--	--	--	--	--	--	--	--	--
1-1/2"	60	--	--	--	--	--	--	--	--	--	--	--
2"	225	100	180	80	140	50	--	--	--	--	--	--
2-1/2"	450	300	400	250	300	180	--	--	--	--	--	--
3"	--	--	750	600	600	500	500	350	--	--	--	--
4"	--	--	--	--	1750	1750	1500	1500	--	750	--	--
6"	--	--	--	--	--	--	--	--	--	--	2000	2000

The values listed in the above table are acceptable per KJWW design standards (max = 6 PSI/100 ft). Other values are given in the code. Use the IPC/UPC table for sizing where values are not listed for the Illinois code.

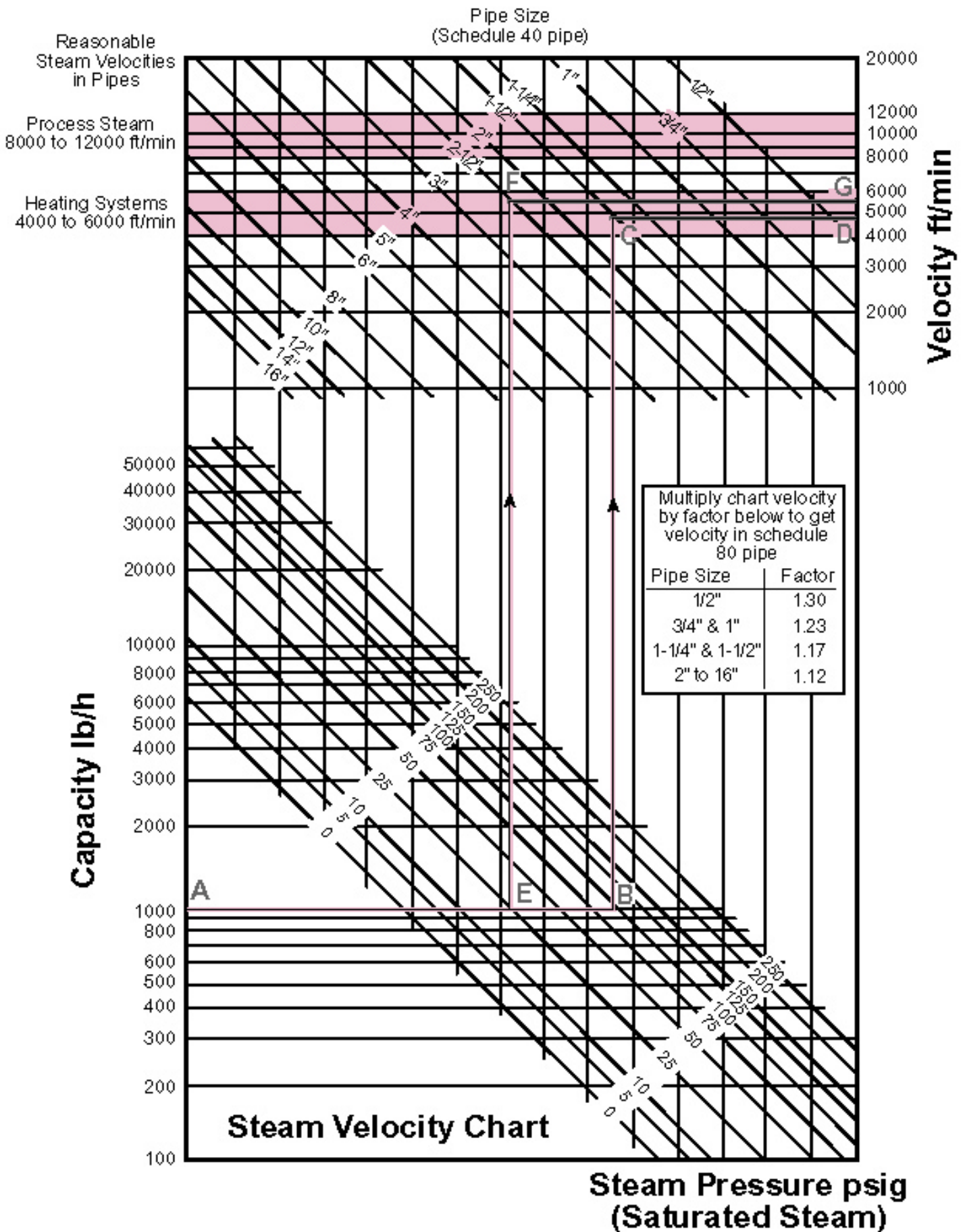
Steam Condensate Drain Pipe Sizing:

Pounds per hour. Based on a dry-closed return system. All pipe sloped 1"/40' or 1/16 .psi/100'

Size	5#	10#	15#	30#	50#	100#	150#
1/2"	240		95	60	42	28	23
3/4"	510		210	130	91	62	50
1"	1000		400	250	180	120	100
1 1/4"	2100		840	520	370	250	200
1 1/2"	3170		1270	780	560	380	310
2"	6240		2500	1540	1110	750	610
2 1/2"	10000		4030	2480	1780	1200	980
3"	18000		7200	4440	3190	2160	1760
4"	37200		14900	9180	6660	4460	3640
6"	110500		44300	27300	19600	13200	10800

Saturated Steam Press vs. Temp:

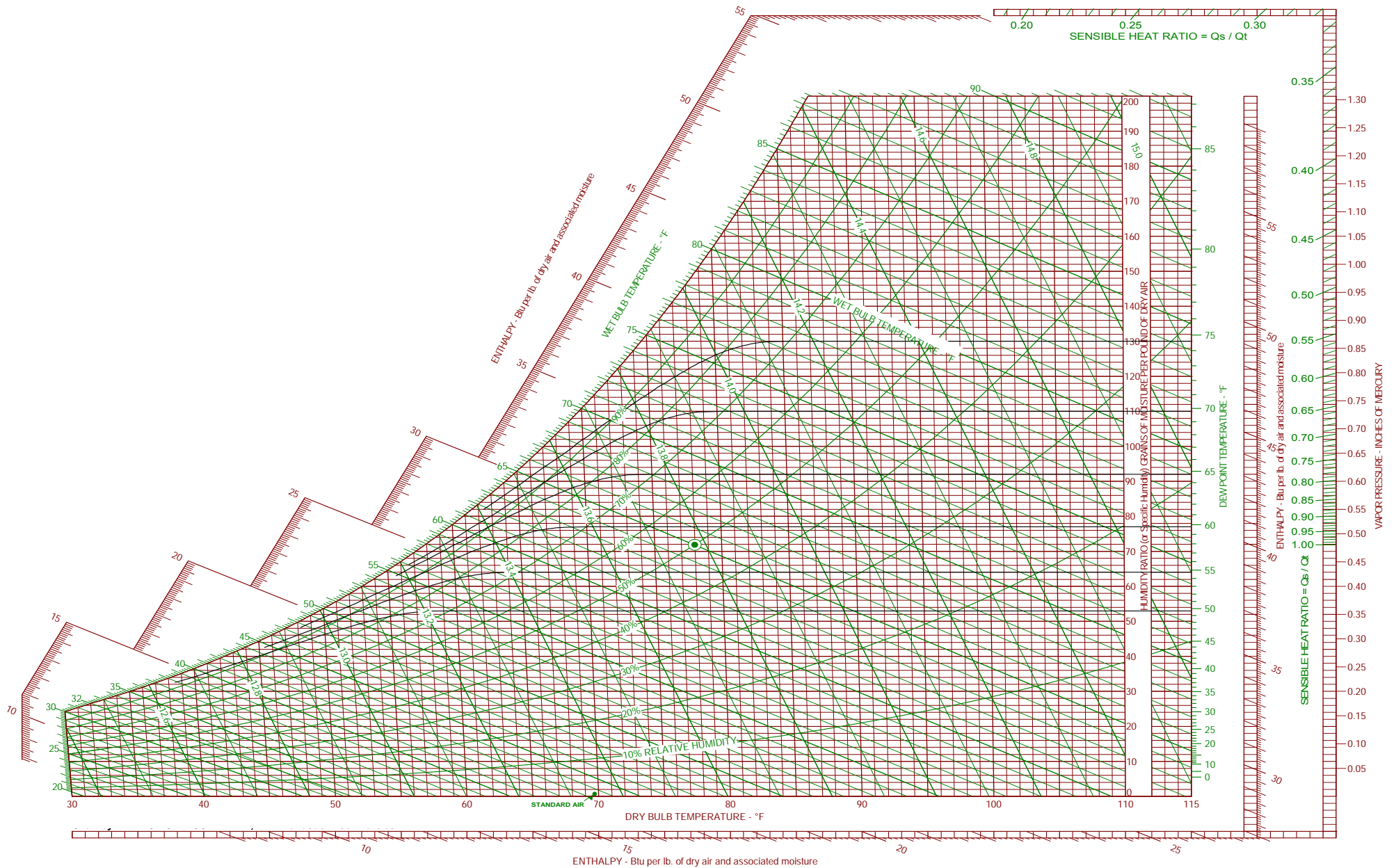
0 #	= 212°F
5 #	= 227°F
10 #	= 240°F
15 #	= 250°F
25 #	= 267°F
50 #	= 297°F
75 #	= 320°F
100 #	= 338°F
120 #	= 350°F
150 #	= 366°F
200 #	= 388°F





# PSYCHROMETRIC CHART

Barometric Pressure 29.921 inches of Mercury



DUCTWORK SIZING TABLES AIR FLOW IN CFM AT

0.08 Friction Factor

CFM	35	100	210	380	610	920	1305	1780	2350	3800	6850	11100	14600	21100	26300	42500	63900	90800
DIA	4	6	8	10	12	14	16	18	20	24	30	36	40	46	50	60	70	80
RECT	CFM																	
4	45	70	105	135	165	195	230	260	295									
6	70	125	180	240	300	360	420	480	545	670	855							
8	105	180	265	355	450	540	635	735	830	1030	1325	1625	1825					
10	135	240	355	480	605	740	875	1010	1150	1425	1850	2280	2570	3000	3290			
12	165	300	450	605	775	945	1125	1305	1485	1855	2420	2995	3380	3960	4345	5315		
14	195	360	540	740	945	1160	1385	1610	1840	2310	3025	3755	4250	4990	5485	6730	7980	
16	230	420	635	875	1125	1385	1650	1925	2210	2780	3665	4560	5170	6085	6700	8240	9795	11350
18	260	480	735	1010	1305	1610	1925	2255	2585	3270	4325	5405	6130	7235	7975	9835	11710	13595
20	295	545	830	1150	1485	1840	2210	2585	2975	3770	5005	6275	7130	8430	9305	11505	13725	15955
24		670	1030	1425	1855	2310	2780	3270	3770	4810	6425	8095	9230	10950	12115	15045	18010	20995
30		855	1325	1850	2420	3025	3665	4325	5005	6425	8660	10980	12565	14985	16620	20765	24970	29220
36			1625	2280	2995	3755	4560	5405	6275	8095	10980	14000	16070	19245	21395	26870	32445	38095
40			1825	2570	3380	4250	5170	6130	7130	9230	12565	16070	18480	22185	24700	31115	37665	44315
46				3000	3960	4990	6085	7235	8430	10950	14985	19245	22185	26710	29795	37690	45785	54025
50				3290	4345	5485	6700	7975	9305	12115	16620	21395	24700	29795	33275	42200	51365	60715
60					5315	6730	8240	9835	11505	15045	20765	26870	31115	37690	42200	53805	65795	78075
70						7980	9795	11710	13725	18010	24970	32445	37665	45785	51365	65795	80770	96170
80							11350	13595	15955	20995	29220	38095	44315	54025	60715	78075	96170	114840
90								15480	18190	23995	33500	43800	51040	62370	70200	90580	111900	133970
100									20435	27000	37800	49545	57820	70805	79795	103260	127895	153465
120										33040	46450	61120	71500	87850	99215	129015	160490	193325
140											55135	72765	85285	105065	118855	155155	193680	234040

0.1 Friction Factor

CFM	40	110	235	425	690	1035	1470	2005	2650	4300	7700	12500	16400	23800	29600	47900	71800	102200
DIA	4	6	8	10	12	14	16	18	20	24	30	36	40	46	50	60	70	80
RECT	CFM																	
4	50	80	115	150	185	220	260	295	330									
6	80	140	205	270	335	405	475	540	610	750	965							
8	115	205	300	400	505	610	715	825	935	1155	1490	1830	2055					
10	150	270	400	540	685	830	980	1135	1290	1605	2085	2565	2890	3375	3700			
12	185	335	505	685	870	1065	1265	1465	1670	2090	2725	3370	3800	4450	4890	5980		
14	220	405	610	830	1065	1305	1555	1810	2070	2595	3405	4225	4780	5615	6170	7570	8980	
16	260	475	715	980	1265	1555	1860	2170	2485	3130	4120	5130	5815	6845	7535	9270	11015	12765
18	295	540	825	1135	1465	1810	2170	2535	2910	3680	4865	6080	6895	8135	8970	11065	13175	15290
20	330	610	935	1290	1670	2070	2485	2910	3345	4245	5635	7060	8025	9485	10470	12945	15440	17950
24		750	1155	1605	2090	2595	3130	3680	4245	5410	7230	9105	10380	12320	13625	16925	20260	23615
30		965	1490	2085	2725	3405	4120	4865	5635	7230	9740	12350	14135	16855	18695	23355	28090	32870
36			1830	2565	3370	4225	5130	6080	7060	9105	12350	15750	18080	21645	24065	30225	36500	42855
40			2055	2890	3800	4780	5815	6895	8025	10380	14135	18080	20790	24955	27785	35000	42370	49850
46				3375	4450	5615	6845	8135	9485	12320	16855	21645	24955	30050	33520	42400	51505	60770
50				3700	4890	6170	7535	8970	10470	13625	18695	24065	27785	33520	37435	47470	57780	68295
60					5980	7570	9270	11065	12945	16925	23355	30225	35000	42400	47470	60525	74015	87825
70						8980	11015	13175	15440	20260	28090	36500	42370	51505	57780	74015	90860	108180
80							12765	15290	17950	23615	32870	42855	49850	60770	68295	87825	108180	129185
90								17415	20465	26990	37685	49275	57415	70160	78970	101890	125875	150700
100									22985	30375	42520	55735	65045	79645	89760	116155	143870	172635
120										37165	52250	68750	80430	98825	111605	145130	180535	217475
140											62020	81855	95935	118190	133700	174535	217870	263275

0.15 Friction Factor

CFM	45	135	295	525	855	1280	1820	2480	3300	5300	9550	15400	20400	29400	36700	59300	89000	126500
DIA	4	6	8	10	12	14	16	18	20	24	30	36	40	46	50	60	70	80
RECT	CFM																	
4	60	100	145	185	230	275	320	365	410									
6	100	175	250	335	415	500	585	670	760	930	1190							
8	145	250	370	495	625	755	890	1025	1160	1435	1850	2265	2545					
10	185	335	495	665	845	1030	1215	1405	1600	1990	2580	3175	3575	4180	4580			
12	230	415	625	845	1080	1320	1565	1815	2070	2585	3375	4170	4705	5515	6055	7405		
14	275	500	755	1030	1320	1620	1925	2240	2565	3215	4215	5235	5920	6950	7640	9380	11120	
16	320	585	890	1215	1565	1925	2300	2685	3075	3875	5105	6355	7200	8475	9330	11480	13645	15810
18	365	670	1025	1405	1815	2240	2685	3140	3605	4555	6025	7525	8540	10075	11110	13705	16315	18935
20	410	760	1160	1600	2070	2565	3075	3605	4145	5255	6975	8740	9935	11745	12965	16030	19120	22225
24		930	1435	1990	2585	3215	3875	4555	5255	6700	8955	11280	12860	15260	16875	20960	25090	29245
30		1190	1850	2580	3375	4215	5105	6025	6975	8955	12065	15295	17505	20875	23150	28925	34785	40705
36			2265	3175	4170	5235	6355	7525	8740	11280	15295	19505	22390	26810	29805	37430	45205	53075
40			2545	3575	4705	5920	7200	8540	9935	12860	17505	22390	25750	30905	34410	43345	52475	61740
46				4180	5515	6950	8475	10075	11745	15260	20875	26810	30905	37215	41510	52510	63785	75265
50				4580	6055	7640	9330	11110	12965	16875	23150	29805	34410	41510	46360	58790	71560	84585
60					7405	9380	11480	13705	16030	20960	28925	37430	43345	52510	58790	74960	91660	108770
70						11120	13645	16315	19120	25090	34785	45205	52475	63785	71560	91660	112525	133980
80							15810	18935	22225	29245	40705	53075	61740	75265	84585	108770	133980	159990
90								21565	25345	33425	46670	61020	71105	86890	97800	126190	155890	186635
100									28465	37615	52660	69025	80550	98640	111165	143855	178175	213800
120										46030	64710	85145	99610	122390	138220	179740	223585	269330
140											76810	101375	118815	146375	165585	216155	269820	326050

**Sizing Tables:**

Terminal Air Box information is provided for understanding of KJWW selection methodology and for selection of boxes in system renovation or small quantities. Selection of multiple boxes for new construction projects should be done by the Indoor Air Quality spreadsheet.

Consult manufacturers'

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Sizing Single Duct Boxes				
TAB Inlet Size (in)	Maximum Air Flow (Cfm) (2000 fpm)	Approximate Static Pressure Drop (in. w.g.)* (Basic with 2 row coil)	Minimum Air Flow (Cfm) (Based on DDC Controls)	NC at Maximum Air Flow** (Discharged/Radiated @ 1" Differential SP)
4	175	0.11	50	25/27
5	275	0.15	70	22/27
6	400	0.37	80	25/28
7	540	0.33	105	25/25
8	700	0.39	145	27/27
9	900	0.36	175	22/24
10	1100	0.45	230	24/29
12	1600	0.48	325	27/30
14	2150	0.45	450	21/28
16	2800	0.50*	580	23/27
24x16	5340	0.76*	1400	37/49

Sizing Parallel Fan Powered Boxes***	
Inlet Size	Box Cfm
6	80-500
8	145-700
10	230-1090
12	325-1570
14	450-2140
16	580-2800

Based on maximum Cfm. KJWW design standard is to specify 0.50" maximum air pressure drop for a typical box. If the pressure drop exceeds the maximum allowable pressure drop, a reheat coil will be required to be installed separate of the TAB. ANSI Standard S12.60-2002 limits the noise in a classroom to 35 dBA, which is roughly equivalent to NC27. Select terminal air boxes for classrooms below this level or get approval from our client. [Note: The values above are NC, **NOT** dBA and are at the space, not at the box.]

\*Consult manufacturers' literature when using parallel fan powered box

**Grilles and Diffusers:**

The following grille and diffuser selections are based on catalog NC ratings of 15 to 20 (not “installed” values - poor installation can add as much as 15-17dB to the catalog values). This is typically necessary to attain a typical office NC requirement of 35. These selections may not be appropriate for spaces with very low or high NC requirements, or spaces with no “soft” surfaces. Refer to Design Manual 15936-1.

<b>Sizing of Typical 24x24 Louvered Face Diffuser (Based on Titus TMS Diffuser, CD-1 in master schedule)</b>		
<b>Round Inlet Size (in)</b>	<b>CFM</b>	<b>Throw (ft) (Terminal Velocity 50 fpm)</b>
6	150	7
8	245	9
10	410	13
12	535	15
14	695	17
15	765	18

<b>Sizing of Typical 24x24 Architectural Panel Face Diffuser (Based on Titus OMNI Diffuser, CD-2 in master schedule)</b>		
<b>Round Inlet Size (in)</b>	<b>CFM</b>	<b>Throw (ft) (Terminal Velocity 50 fpm)</b>
6	165	7
8	265	11
10	435	14
12	580	16
14	750	19
15	840	20

<b>Sizing of Typical 24x24 Ducted Perforated Return Grilles (Based on Titus PAR Grilles, RG-4 in master schedule)</b>	
<b>Round Inlet Size (in)*</b>	<b>CFM</b>
6	155
8	235
10	325
12	440
14	525
16	600

<b>Sizing of Typical Non-Ducted Perforated Return Grilles (Based on Titus PXP Grilles, RG-1 &amp; 2 in master schedule)</b>	
<b>Face Size (in)</b>	<b>CFM</b>
24x12	500
24x24	1000

\*Grilles are available with rectangular hard duct connections that can handle higher airflow rates at a lower NC. See manufacturers’ catalog for details.

<b>Sizing of Typical Ducted Supply Grilles (Based on Titus 300RL Grilles with double deflection with blades in the Long Direction, assuming 22.5° blade angles, SG-1 in master schedule)*</b>			<b>Sizing of Typical Ducted Return/Exhaust Grilles (Based on Titus 350RL with 35° single deflection blades in the Long Direction, RG-3 in the master schedule)**</b>	
<b>Nominal Duct Size (in)</b>	<b>CFM</b>	<b>Throw (FT)</b>	<b>Nominal Duct Size (in)</b>	<b>CFM</b>
6x6	115	15	6x6	75
8x6	150	18	12x6	165
10x6, 8x8	200	20	12x8, 10x10	225
18x6, 12x8, 10x10	300	24	12x12	265
20x6, 12x10	400	28	18x12, 14x14	400

Sizing of Typical Ducted Supply Grilles (Based on Titus 300RL Grilles with double deflection with blades in the Long Direction, assuming 22.5° blade angles, SG-1 in master schedule)*			Sizing of Typical Ducted Return/Exhaust Grilles (Based on Titus 350RL with 35° single deflection blades in the Long Direction, RG-3 in the master schedule)**	
Nominal Duct Size (in)	CFM	Throw (FT)	Nominal Duct Size (in)	CFM
24x6, 18x8, 12x12	450	30	22x10, 16x16	500
30x6, 18x10, 14x14	575	35	24x12, 18x18	600
36x6, 18x12, 16x14	675	37	34x10, 20x20	775
30x8, 24x10, 16x16	750	39	24x20	900
30x10, 24x12, 18x16	900	42	22x22	950
28x12, 20x16, 18x18	1000	44	24x24	1100
30x12, 24x16, 20x20	1200	50	36x18	1200
36x12, 26x16, 22x22	1300	51	34x22, 28x28	1400
38x14, 30x18, 24x24	1600	55	36x24, 30x30	1500
42x16, 36x18, 26x26	1800	60	46x22, 32x32	1700
44x16, 36x20, 28x28	2000	65	36x30, 34x34	1900
48x18, 42x20, 30x30	2300	68	48x24, 36x32	2000
48x20, 42x24	2600	73	48x30, 38x38	2200
32x32	2800	75	48x36, 42x42	2500
48x24, 34x34	3000		48x42, 46x46	3200

\* Note: Specifying 45° blade adjustment adds approximately 7 to the NC value (22 to 27 total).

\*\* Note: If 0° blade angle is used, airflow rates can increase. Angled blades are more aesthetically pleasing because the occupants cannot see inside the duct. Grille NC levels vary. Verify specific NC levels with manufacturers’ literature. If this type of grille is mounted above head height it should be installed upside down, or else the angled blades don’t block views into the grille.