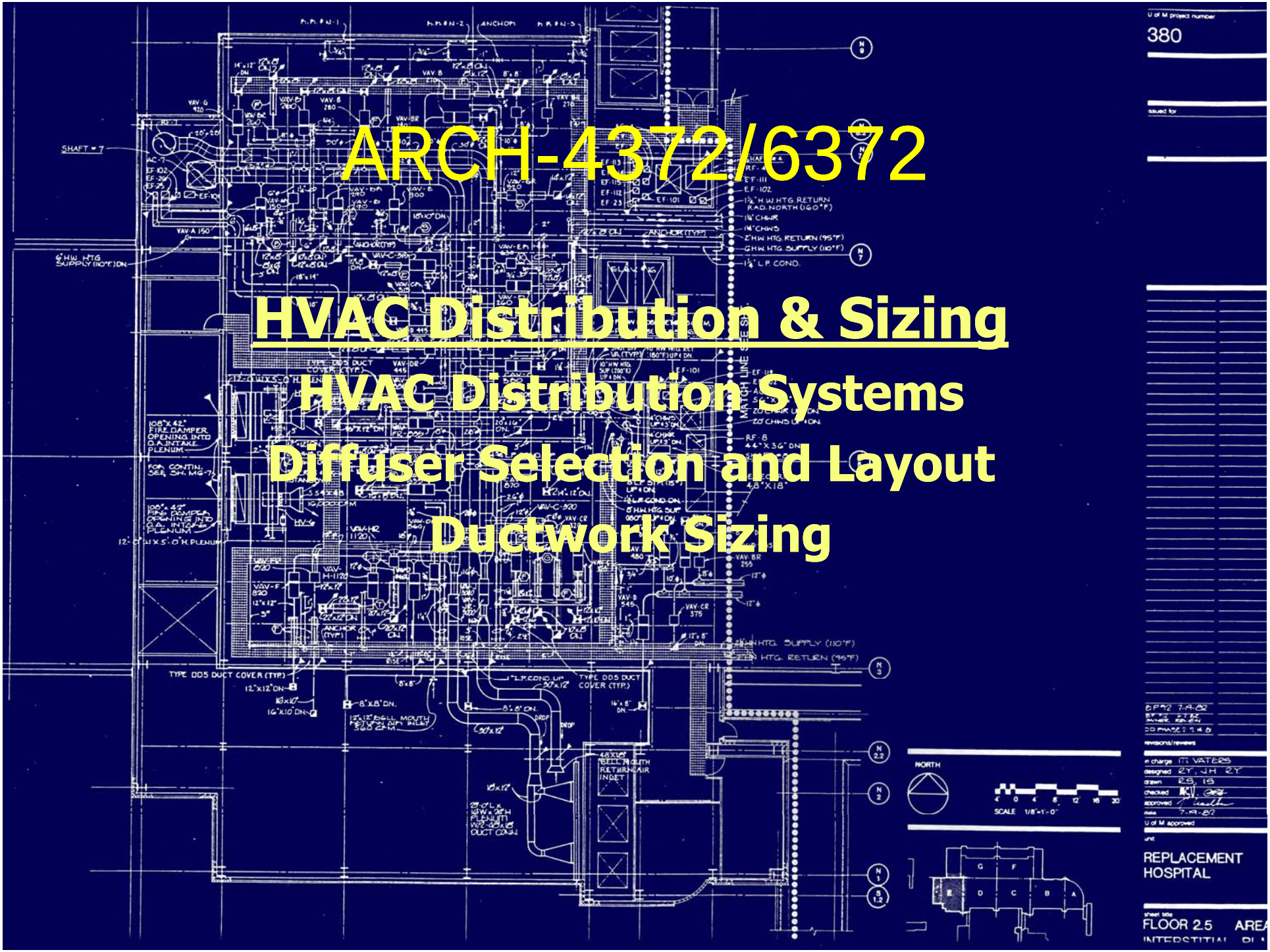
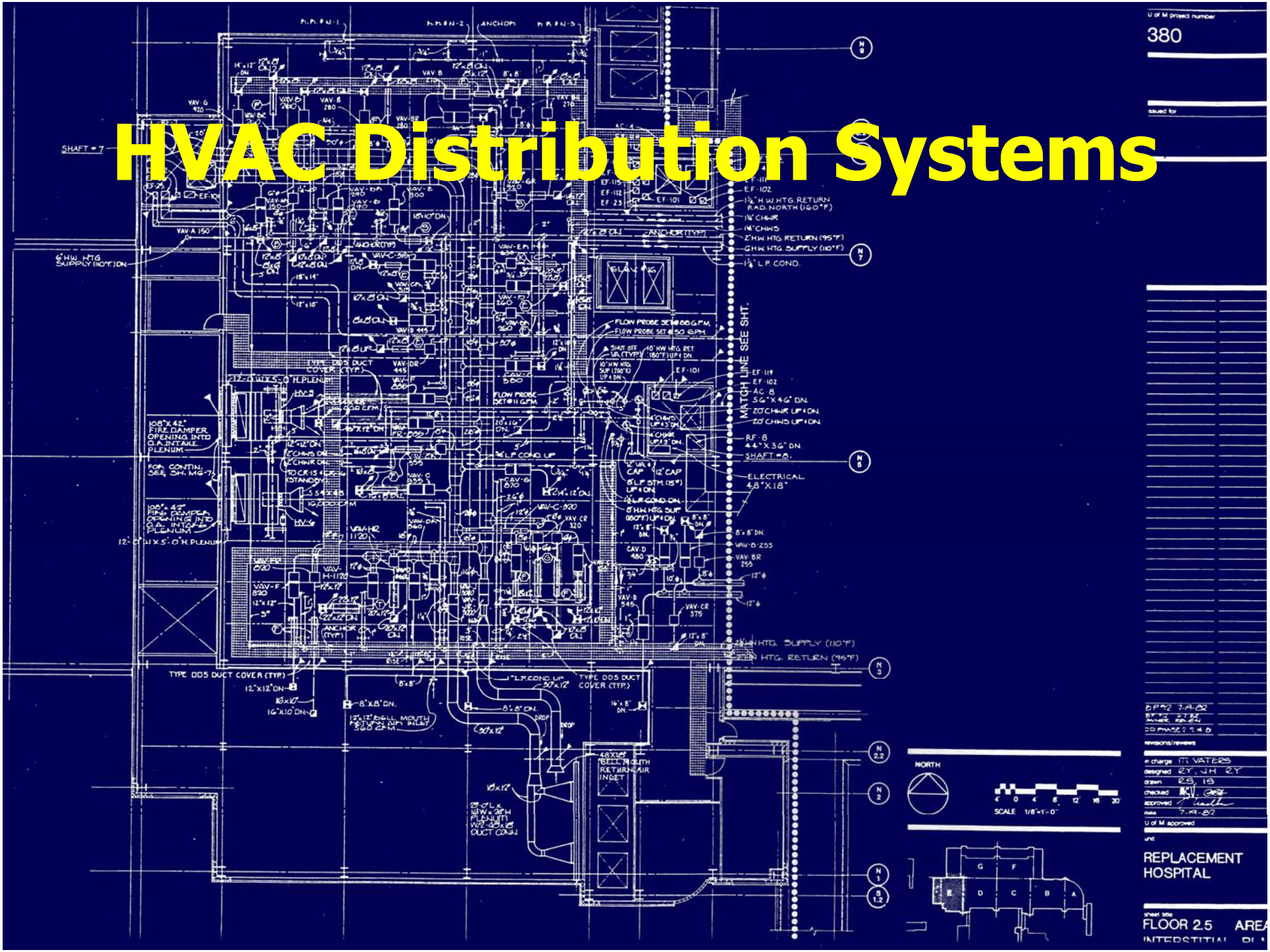

ARCH-4372/6372
HVAC Distribution & Sizing
HVAC Distribution Systems
Diffuser Selection and Layout
Ductwork Sizing
U of M project number
380
issued for
REPLACEMENT
HOSPITAL
FLOOR 2.5


HVAC Distribution Systems
U of M project number
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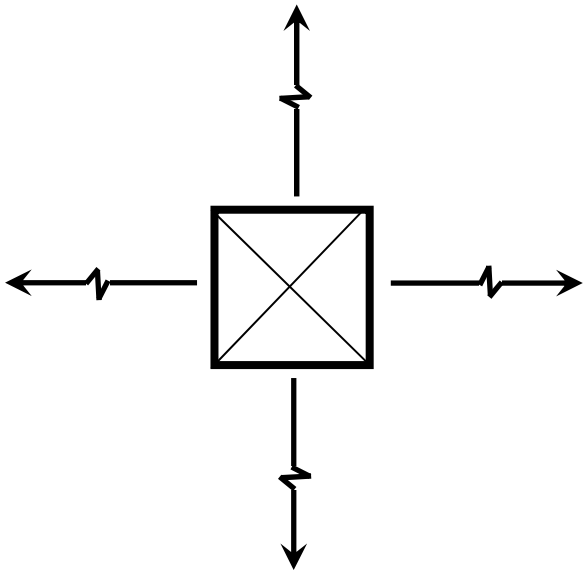
FLOOR 2.5
MATCH LINE SEE SHT.
NORTH
SCALE 1/8"=1'-0"

Distribution System Plans Symbols

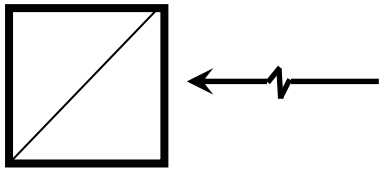
Positive Pressure (supply)

Negative Pressure (return or exhaust)

Distribution System Plans Symbols



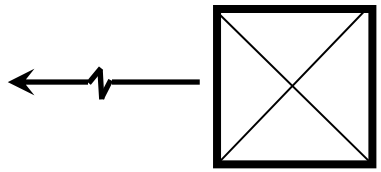
Arrow indicates air flow direction



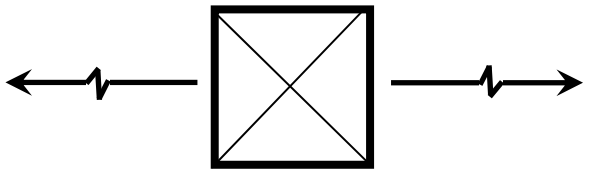
Distribution System Plans Symbols

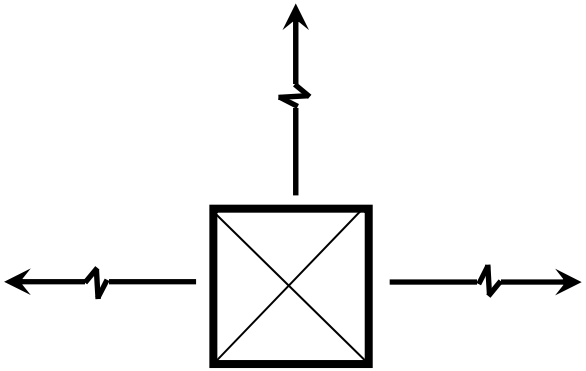
Flow patterns

1-way

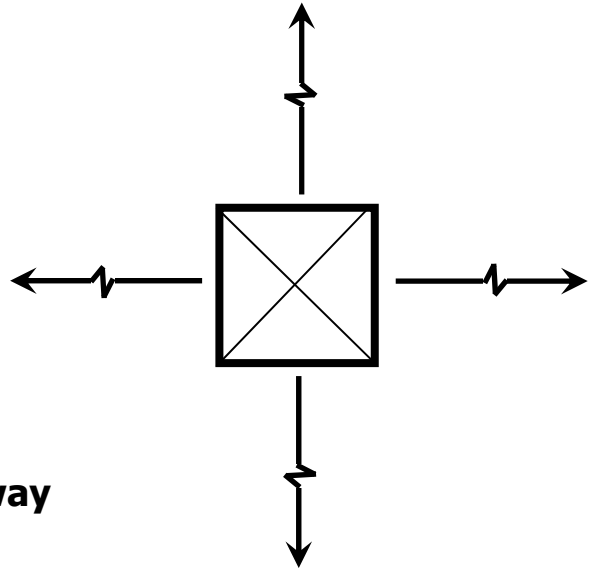


2-way



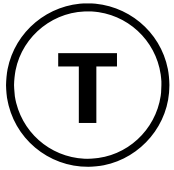


3-way

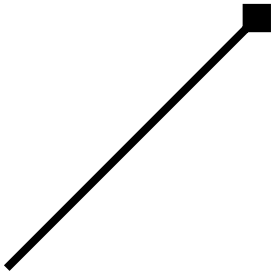


4-way

Distribution System Plans Symbols

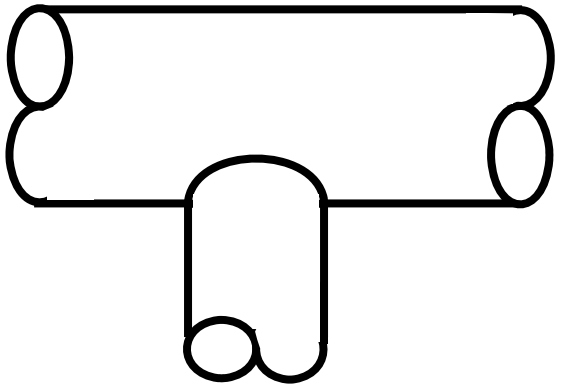


Thermostat

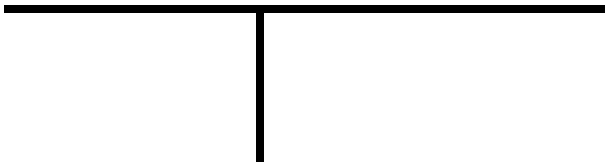


Smoke/Fire Damper

Distribution System Plans Symbols

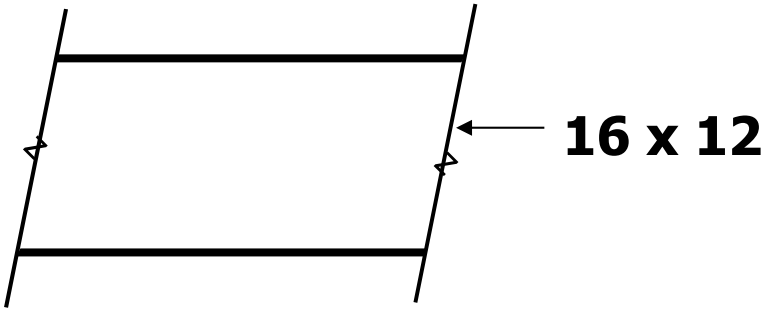


Double Line

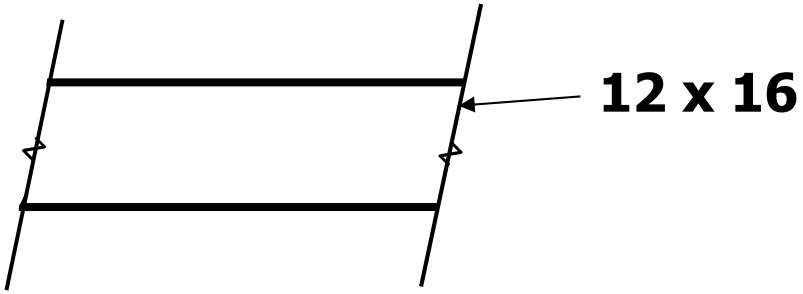


Single Line

Distribution System
Plans Symbols

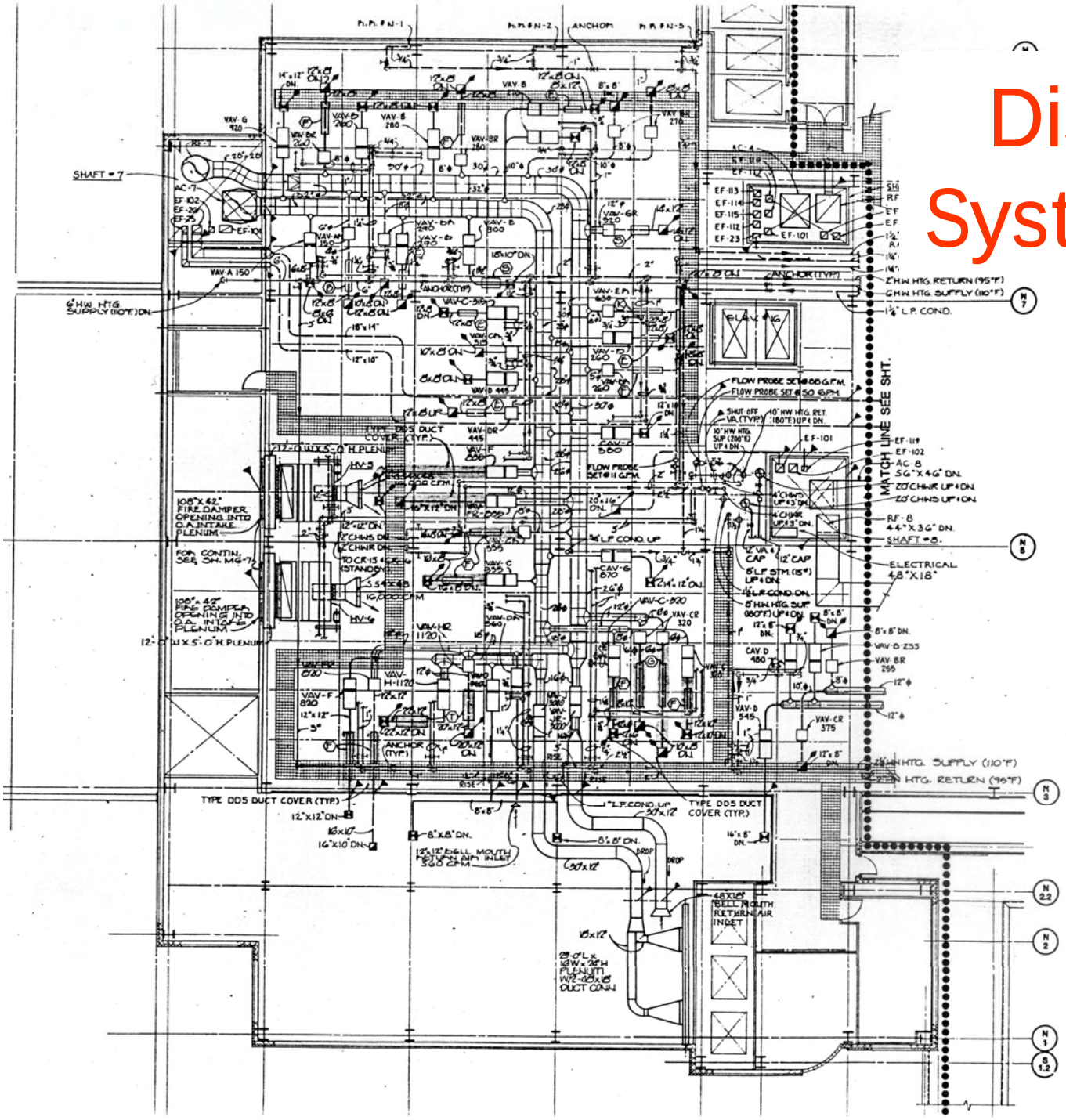


Plan



Section

Distribution System Plans



U of M project number
380

BP'92 7-A-82
ST. 12 2-1-82
SHOWER RM-DN
DD PHASE 2 & 3

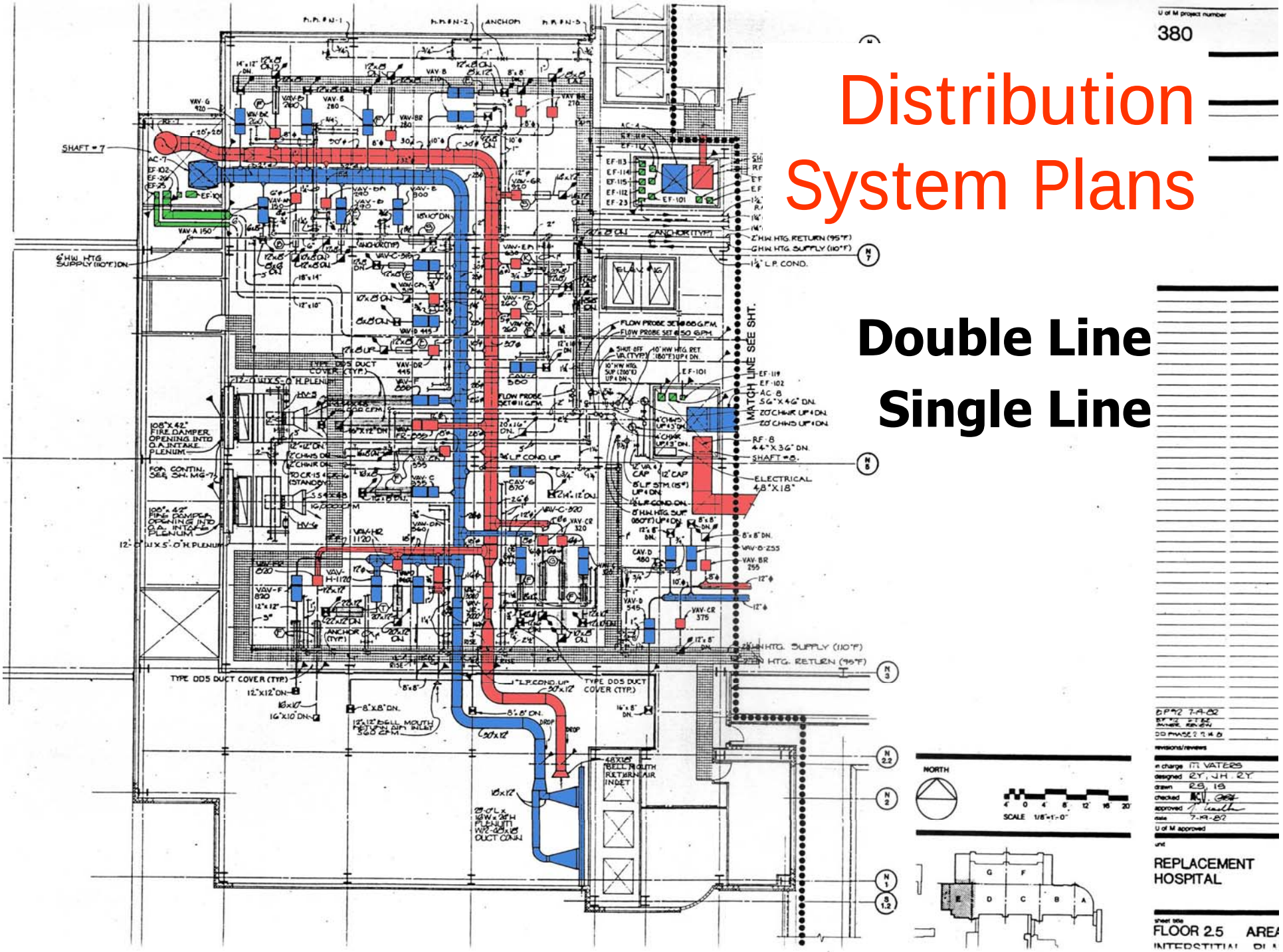
revisions/reviews

in charge M. WATERS
designed RY, JH, RY
drawn RS, TB
checked RCV, CBS
approved
date 7-19-82

U of M approved

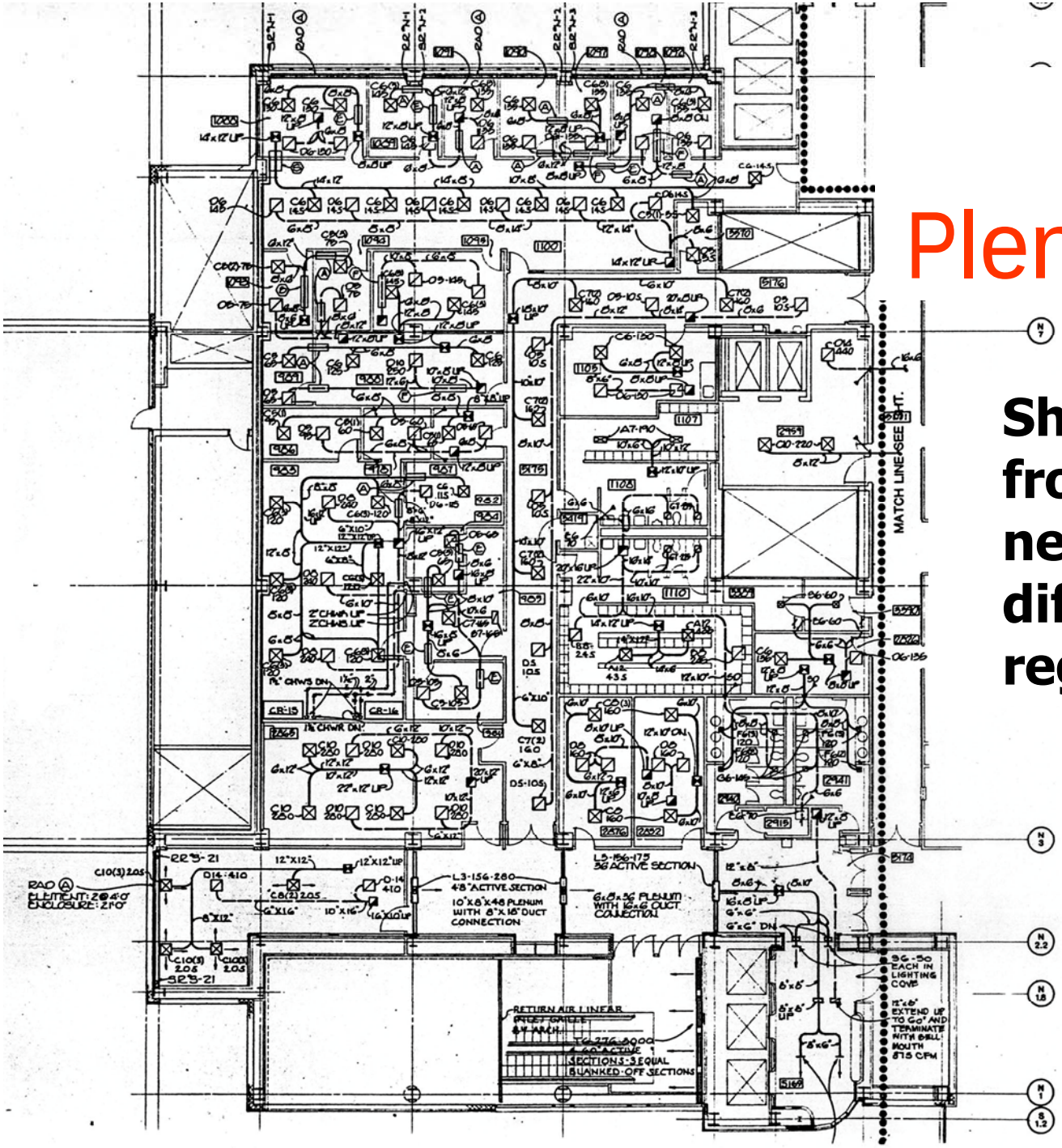
unit
REPLACEMENT HOSPITAL

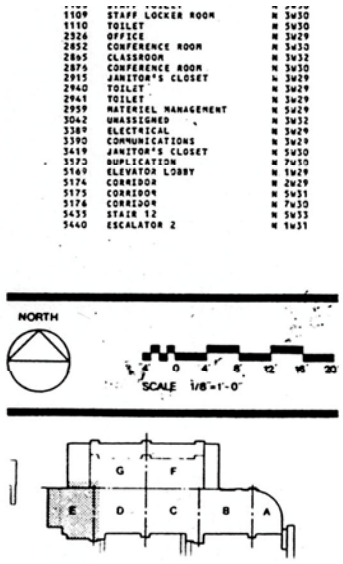
sheet title
FLOOR 2.5 AREA
INTERSTITIAL PLAN


Distribution
System Plans
Double Line
Single Line
U of M project number
380
REPLACEMENT
HOSPITAL
FLOOR 2.5

Ceiling Plenum Plans

Shows duct path from distribution network to supply diffuser or return register





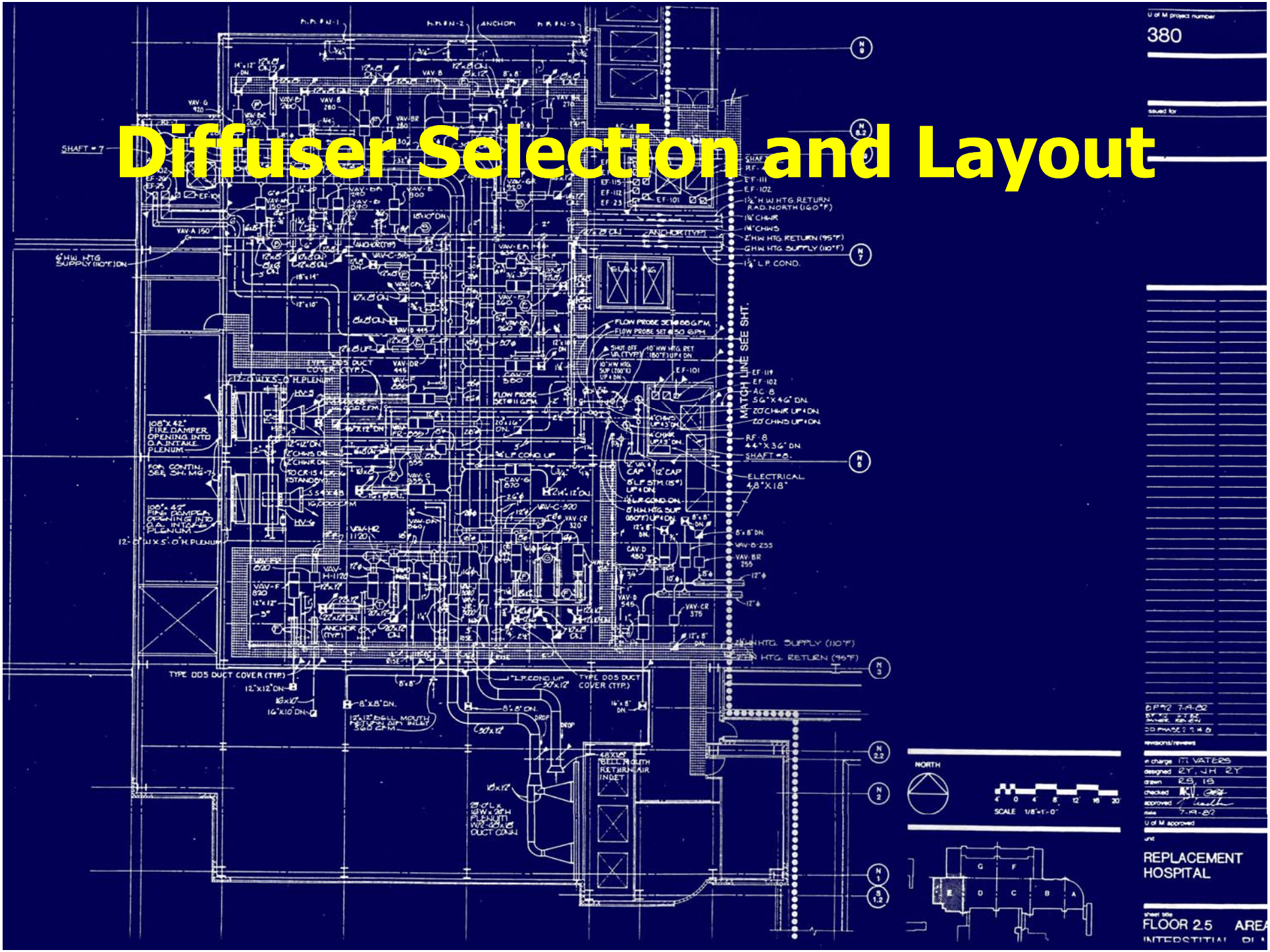
U of M project number
380

DATE 7-19-82
revisions/reviews

in charge M. WATERS
designed R.Y., J.H., R.Y.
drawn S.T.
checked M.G.V.
approved
date 7-19-82.
U of M approved

unit
REPLACEMENT HOSPITAL

sheet title
FLOOR 2 ARE


Diffuser Selection and Layout
U of M project number
380
issued for
REPLACEMENT HOSPITAL
FLOOR 2.5
NORTH
SCALE 1/8"=1'-0"

Diffuser Selection

Diffuser Selection Criteria

- **Air flow**
- **Throw**
- **Noise Criteria (NC) Level**
- **Appearance**

Diffuser Selection

Air Flow

Throw

NC Level

Performance Data TXS & TXR

24 x 24 Module Size

Duct Size	Neck Velocity, FPM		300	400	500	600	700	800	1000	1200	1400
	Vel. Press., In. W.G.		.006	.010	.016	.023	.031	.040	.063	.090	.123
5" RD	Tot. Press., In. W.G.		.010	.018	.028	.040	.054	.070	.110	.157	.215
	Flow Rate, CFM		40	55	70	80	95	110	135	165	190
	NC		—	—	14	19	23	27	33	38	42
	Throw, Ft.	4-WAY	1-2-4	2-2-5	2-3-6	2-4-7	3-5-7	3-6-8	5-6-9	6-7-10	6-7-10
		3-WAY	1-2-4	2-3-6	2-3-7	2-4-8	3-5-9	4-6-10	5-7-10	6-8-12	6-9-13
		2-WAY	1-2-5	2-3-6	2-4-8	3-5-10	4-6-10	4-7-12	6-8-13	7-10-14	7-10-15
		1-WAY	2-3-6	2-4-8	3-5-9	4-6-10	5-7-11	6-8-13	6-9-13	8-10-14	9-10-15
6" RD	Tot. Press., In. W.G.		.013	.021	.034	.048	.065	.084	.132	.189	.258
	Flow Rate, CFM		60	80	100	120	140	160	200	235	275
	NC		—	—	17	22	26	30	36	41	45
	Throw, Ft.	4-WAY	1-2-4	2-3-5	3-3-7	3-4-8	3-5-8	3-6-9	5-7-10	6-8-10	7-8-11
		3-WAY	1-2-4	2-3-6	3-3-8	3-4-9	3-5-10	4-6-10	5-8-11	6-9-13	7-10-14
		2-WAY	1-2-5	2-3-7	3-4-9	3-5-10	4-6-11	4-7-12	6-9-14	7-10-15	8-11-17
		1 WAY	2-3-6	3-4-9	3-5-11	4-6-11	5-8-12	6-9-13	7-10-15	9-10-16	10-12-17
7" RD or 6 x 6	Tot. Press., In. W.G.		.014	.023	.037	.053	.071	.092	.145	.207	.283
	Flow Rate, CFM		80	105	135	160	190	215	270	320	375
	NC		—	13	19	24	28	32	38	43	47
	Throw, Ft.	4-WAY	1-2-5	2-3-6	3-4-9	3-5-10	4-6-10	4-8-11	6-9-12	8-10-13	9-10-14
		3-WAY	1-2-5	2-4-7	3-4-10	3-5-11	4-6-12	5-8-13	6-10-14	7-11-16	9-12-17
		2-WAY	1-2-6	2-4-9	3-5-11	4-6-12	5-8-14	5-9-15	7-11-17	9-13-18	10-14-20
		1-WAY	2-4-8	3-5-11	4-6-12	5-8-13	6-10-14	8-11-15	9-12-17	11-13-18	12-14-20
8" RD	Tot. Press., In. W.G.		.014	.024	.038	.055	.075	.096	.151	.216	.295
	Flow Rate, CFM		105	140	175	210	245	280	350	420	490
	NC		—	17	23	28	32	36	42	47	51
	Throw, Ft.	4-WAY	1-3-6	2-4-8	4-4-10	4-6-11	4-7-12	5-8-12	6-10-13	8-11-14	9-12-16
		3-WAY	1-3-6	2-4-8	4-5-11	4-6-13	5-7-13	5-9-14	7-11-16	9-13-18	10-13-19
		2-WAY	1-3-7	2-5-10	4-6-12	4-7-14	5-8-15	6-10-17	8-12-19	10-14-21	12-16-22
		1-WAY	3-4-9	4-6-12	5-7-13	6-9-14	7-10-15	8-12-17	10-13-19	13-14-21	13-16-22

Diffuser Selection

Throw:

Distance of air movement

Avoid

- **Gaps and overlap**
- **Obstructions/deflectors**

Velocity (fpm)

150 **100** **50**

Throw, Ft.	4-WAY	1-2-4	2-3-5	3-3-7
	3-WAY	1-2-4	2-3-6	3-3-8
	2-WAY	1-2-5	2-3-7	3-4-9
	1 WAY	2-3-6	3-4-9	3-5-11

Diffuser Layout

1. **Use Room Sensible Load (no latent, no ventilation) to determine air flow**

$$Q_s = 1.08 \times CFM \times \Delta T$$

where

$$T = |T_{sa} - T_{ra}|$$

thus

$$CFM = \frac{Qs}{(1.08 \times \Delta T)}$$

Diffuser Layout

2. Define Supply Air temperatures

Heating:

T_{sa} range is 90-110ºF

T_{ra}=68ºF

Cooling:

T_{sa} range is 45-55ºF

T_{ra}=78ºF

Diffuser Layout

3. Define ΔT

Heating:

$$\Delta T = |110-68| = 42^{o}F$$

Cooling:

$$\Delta T = |55-78| = 23^{o}F$$

Diffuser Layout

4. Determine Air Flow (CFM)

$$CFM_{htg} = \frac{Qs}{(1.08 \times \Delta T_{htg})}$$

$$CFM_{clg} = \frac{Qs}{(1.08 \times \Delta T_{clg})}$$

Larger result determines air flow

Diffuser Layout

5. Revise discharge air temperature to match required air flow

$$CFM_{peak} = \frac{Qs}{(1.08 \times |T_{sa} - T_{ra}|)}$$

solve for T_{sa}

Diffuser Layout

6. Select diffuser layout

Regular pattern

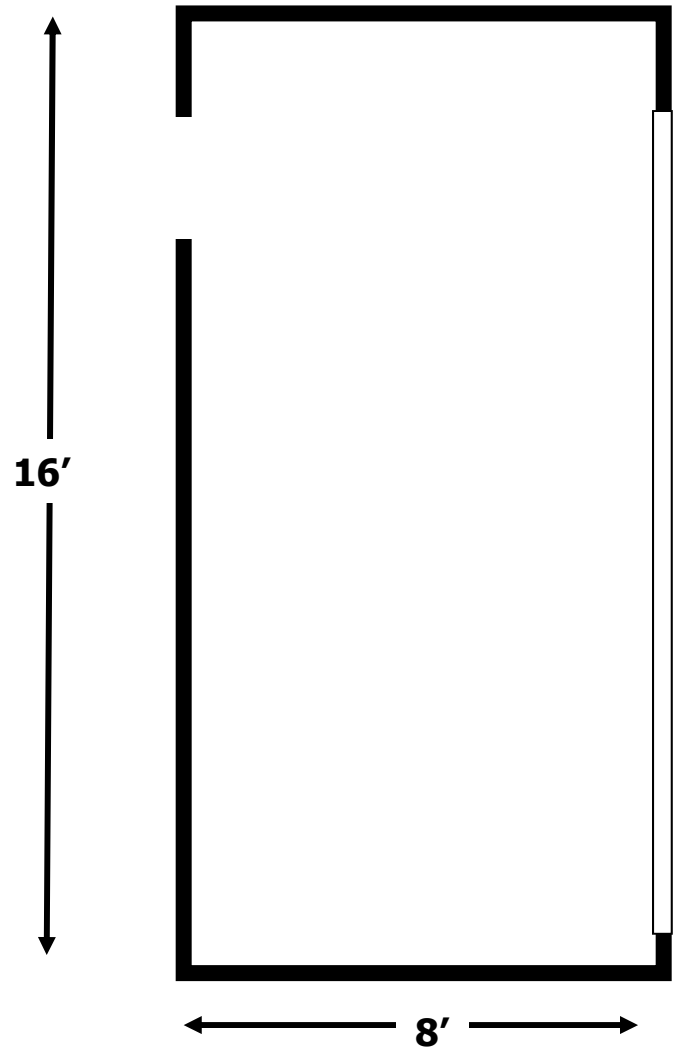
Uniform coverage

Avoid "short circuiting" with exhaust/return registers

Diffuser Layout Example

Office space with overhead heating and cooling supply

NC level 35



Diffuser Layout Example

Heating Qs= 11,800 Btuh @ 68ºF

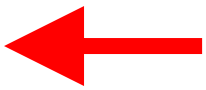
Cooling Qs=8,600 Btuh @ 78ºF

$$CFM_{htg} = \frac{Qs}{(1.08 \times \Delta T)}$$

=11,800/(1.08 x 42)=260 CFM

$$CFM_{clg} = \frac{Qs}{(1.08 \times \Delta T)}$$

=8,600/(1.08 x 23)=346 CFM



Diffuser Layout Example

Revise Heating T_{sa}

$$CFM_{peak} = \frac{Qs}{(1.08 \times \Delta T)}$$

$$= 346 = 11{,}800/(1.08 \times |T_{sa} - 68|)$$

$$T_{sa} = 99.6^{o}F$$

Diffuser Layout Example

Define Pattern

346 Cfm

Round up to 0 or 5 cfm

1@350 cfm
2@175=350 cfm
3@115=345 cfm
4@90=360 cfm

Diffuser Layout Example

Define Pattern

346 Cfm

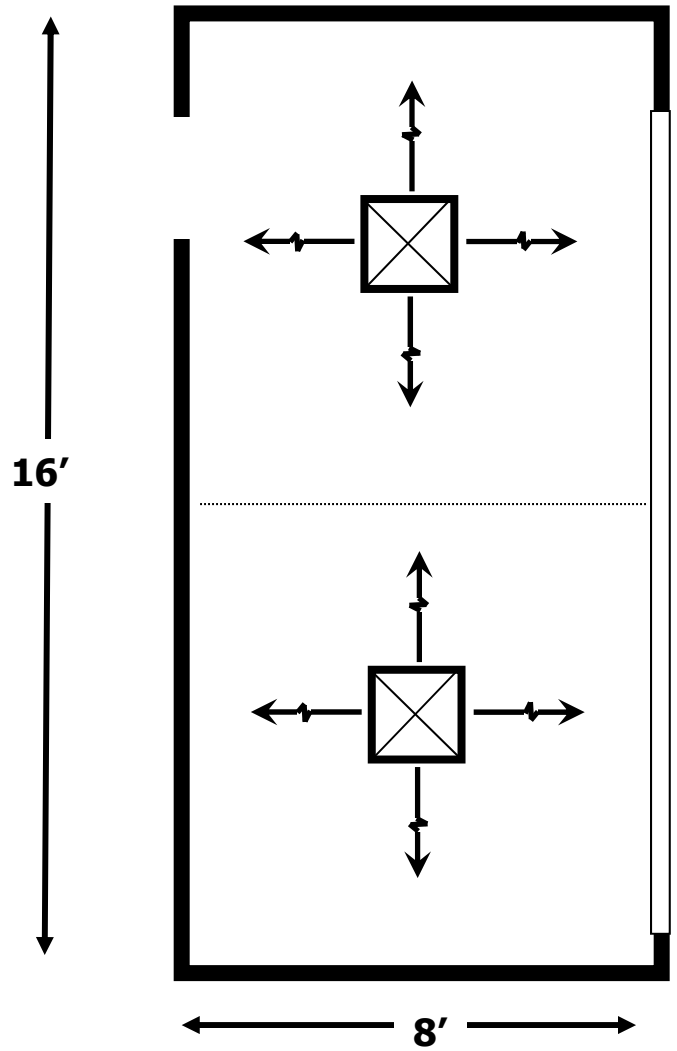
Round up to 0 or 5 cfm

1@350 cfm 2-way

2@175=350 cfm 4-way

3@115=345 cfm 3-way

4@90=360 cfm 2-way



Diffuser Selection

NC 35

Air Flow

Throw

Select 8″ Rd 4-way

Performance Data TXS & TXR

24 x 24 Module Size

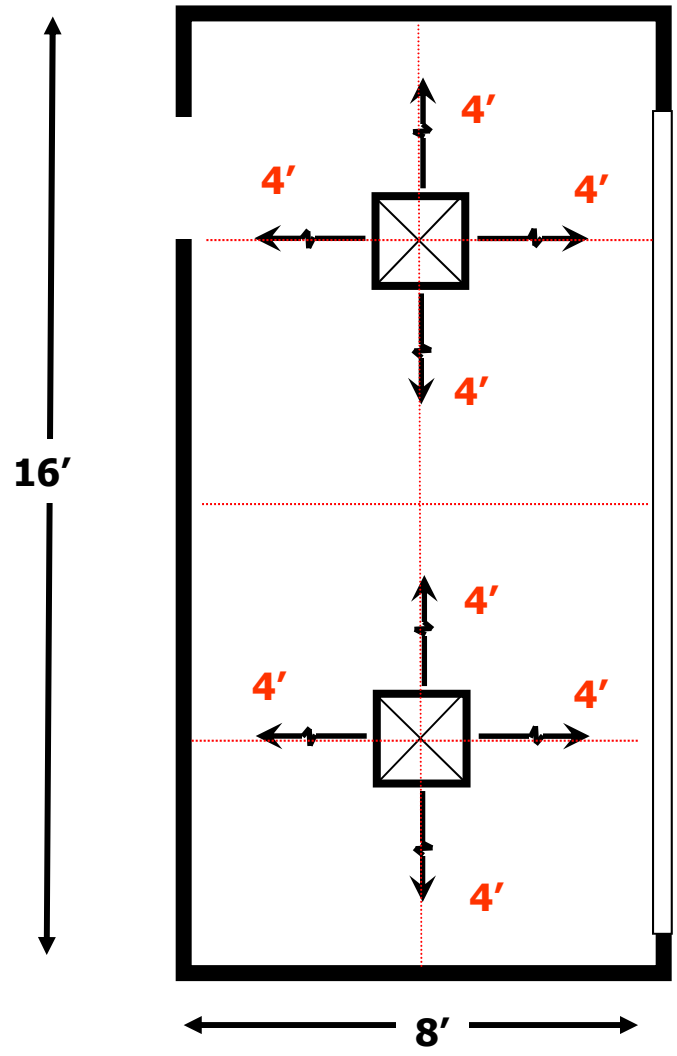
Duct Size	Neck Velocity, FPM		300	400	500	600	700	800	1000	1200	1400
	Vel. Press., In. W.G.		.006	.010	.016	.023	.031	.040	.063	.090	.123
5″ RD	Tot. Press., In. W.G.		.010	.018	.028	.040	.054	.070	.110	.157	.215
	Flow Rate, CFM		40	55	70	80	95	110	135	165	190
	NC		—	—	14	19	23	27	33	38	42
	Throw, Ft.	4-WAY	1-2-4	2-2-5	2-3-6	2-4-7	3-5-7	3-6-8	5-6-9	6-7-10	6-7-10
		3-WAY	1-2-4	2-3-6	2-3-7	2-4-8	3-5-9	4-6-10	5-7-10	6-8-12	6-9-13
		2-WAY	1-2-5	2-3-6	2-4-8	3-5-10	4-6-10	4-7-12	6-8-13	7-10-14	7-10-15
		1-WAY	2-3-6	2-4-8	3-5-9	4-6-10	5-7-11	6-8-13	6-9-13	8-10-14	9-10-15
6″ RD	Tot. Press., In. W.G.		.013	.021	.034	.048	.065	.084	.132	.189	.258
	Flow Rate, CFM		60	80	100	120	140	160	200	235	275
	NC		—	—	17	22	26	30	36	41	45
	Throw, Ft.	4-WAY	1-2-4	2-3-5	3-3-7	3-4-8	3-5-8	3-6-9	5-7-10	6-8-10	7-8-11
		3-WAY	1-2-4	2-3-6	3-3-8	3-4-9	3-5-10	4-6-10	5-8-11	6-9-13	7-10-14
		2-WAY	1-2-5	2-3-7	3-4-9	3-5-10	4-6-11	4-7-12	6-9-14	7-10-15	8-11-17
		1 WAY	2-3-6	3-4-9	3-5-11	4-6-11	5-8-12	6-9-13	7-10-15	9-10-16	10-12-17
7″ RD or 6 x 6	Tot. Press., In. W.G.		.014	.023	.037	.053	.071	.092	.145	.207	.283
	Flow Rate, CFM		80	105	135	160	190	215	270	320	375
	NC		—	13	19	24	28	32	38	43	47
	Throw, Ft.	4-WAY	1-2-5	2-3-6	3-4-9	3-5-10	4-6-10	4-8-11	6-9-12	8-10-13	9-10-14
		3-WAY	1-2-5	2-4-7	3-4-10	3-5-11	4-6-12	5-8-13	6-10-14	7-11-16	9-12-17
		2-WAY	1-2-6	2-4-9	3-5-11	4-6-12	5-8-14	5-9-15	7-11-17	9-13-18	10-14-20
		1-WAY	2-4-8	3-5-11	4-6-12	5-8-13	6-10-14	8-11-15	9-12-17	11-13-18	12-14-20
8″ RD	Tot. Press., In. W.G.		.014	.024	.038	.055	.075	.096	.151	.216	.295
	Flow Rate, CFM		105	140	175	210	245	280	350	420	490
	NC		—	17	23	28	32	36	42	47	51
	Throw, Ft.	4-WAY	1-3-6	2-4-8	4-4-10	4-6-11	4-7-12	5-8-12	6-10-13	8-11-14	9-12-16
		3-WAY	1-3-6	2-4-8	4-5-11	4-6-13	5-7-13	5-9-14	7-11-16	9-13-18	10-13-19
		2-WAY	1-3-7	2-5-10	4-6-12	4-7-14	5-8-15	6-10-17	8-12-19	10-14-21	12-16-22
		1-WAY	3-4-9	4-6-12	5-7-13	6-9-14	7-10-15	8-12-17	10-13-19	13-14-21	13-16-22

Diffuser Layout Example

Define Pattern

346 Cfm

2@175=350 cfm 4-way



Return Register Selection

Selection Criteria

- **Air flow**
- **Noise Criteria (NC) Level**
- **Appearance**

Return Register Selection

Air Flow

NC Level

Return Grille & Register Performance

Core Style 25R Steel, 30° Louvers

Core Area Square Feet	Nominal Size			Core Vel	400	500	600	700	800	900	1000	1100	1200	1300
				Vel. Press	.010	.016	.022	.031	.040	.050	.062	.075	.090	.105
				Neg. SP	.042	.067	.094	.130	.169	.212	.262	.317	.379	.444
.15	7x4			CFM	60	75	90	105	120	135	150	165	180	195
	6x5			NC	—	—	—	15	20	25	29	33	36	39
.18	8x4	6x6		CFM	72	90	108	126	144	162	180	198	216	234
	7x5			NC	—	—	11	17	22	26	30	34	38	41
.22	10x4	7x6		CFM	88	110	132	154	176	198	220	242	264	286
	8x5			NC	—	—	12	18	23	28	32	36	39	42
.26	12x4	8x6		CFM	104	130	156	182	208	234	260	286	312	338
	10x5			NC	—	—	13	19	24	29	33	37	40	43
.30	14x4			CFM	120	150	180	210	240	270	300	330	360	390
				NC	—	—	14	20	25	30	34	38	41	44
.34	16x4	10x6		CFM	136	170	204	238	272	306	340	374	408	442
	12x5			NC	—	—	15	21	26	31	35	39	42	45
.39	18x4	12x6		CFM	156	195	234	273	312	351	390	429	468	507
	14x5	8x8		NC	—	—	16	22	27	32	36	40	43	46
.46	20x4	14x6		CFM	184	230	276	322	368	414	460	506	552	598
	16x5	10x8		NC	—	10	17	23	29	33	37	41	44	48
.52	24x4	16x6		CFM	208	260	312	364	416	468	520	572	624	676
	18x5			NC	—	11	18	24	29	34	38	42	45	48
.60	28x4	18x6	10x10	CFM	240	300	360	420	480	540	600	660	720	780
	20x5	12x8		NC	—	12	19	25	31	35	39	43	46	50
.69	30x4	20x6	12x10	CFM	276	345	414	483	552	621	690	759	828	897
	24x5	14x8		NC	—	13	20	26	32	36	40	44	47	51
.81	36x4	22x6	14x10	CFM	324	405	486	567	648	729	810	891	972	1053
	28x5	16x8		NC	—	14	21	28	33	37	41	45	49	52
.90	40x4	26x6	16x10	CFM	360	450	540	630	720	810	900	990	1080	1170
	30x5	18x8	12x12	NC	—	15	22	28	34	38	42	46	49	52
1.07	48x4	30x6	14x12	CFM	428	535	642	749	856	963	1070	1177	1284	1391
	36x5	18x10		NC	—	16	24	30	35	39	43	47	51	54

Return Register Layout

Avoid

- **Short circuiting with supply diffusers**
- **Locating in visually obtrusive location**

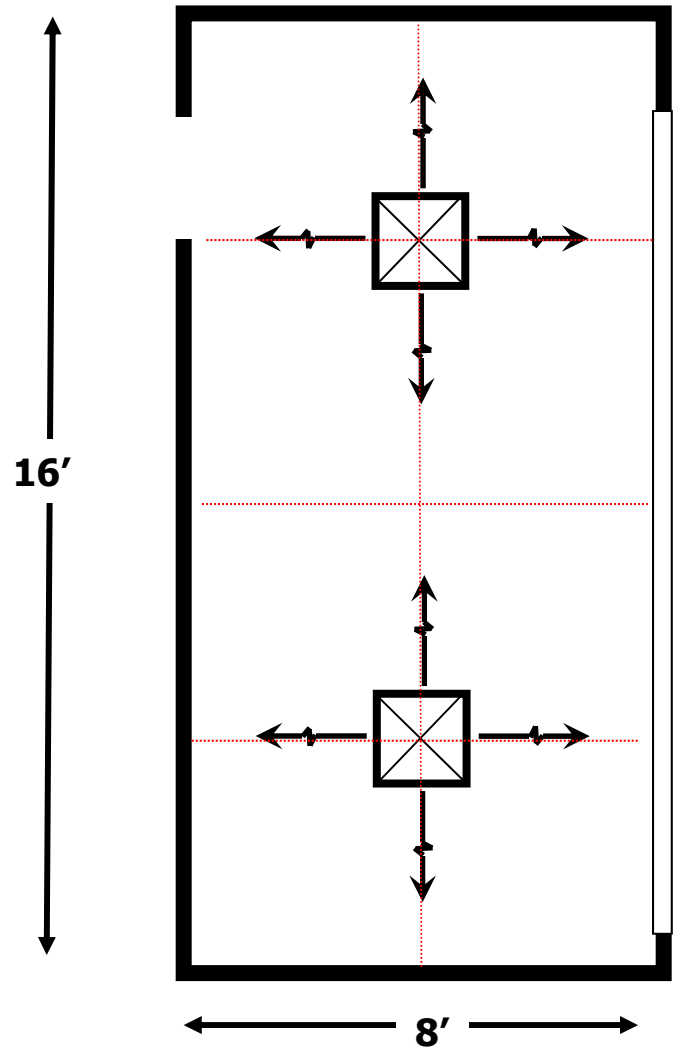
Return Register Layout

Define Pattern

Supply=350 cfm

Return

1@350=350 cfm



Return Register Selection

Air Flow 350 cfm

NC Level 35

Select
10” x 8”
350 cfm
NC 27db

Return Grille & Register Performance

Core Style 25R Steel, 30° Louvers

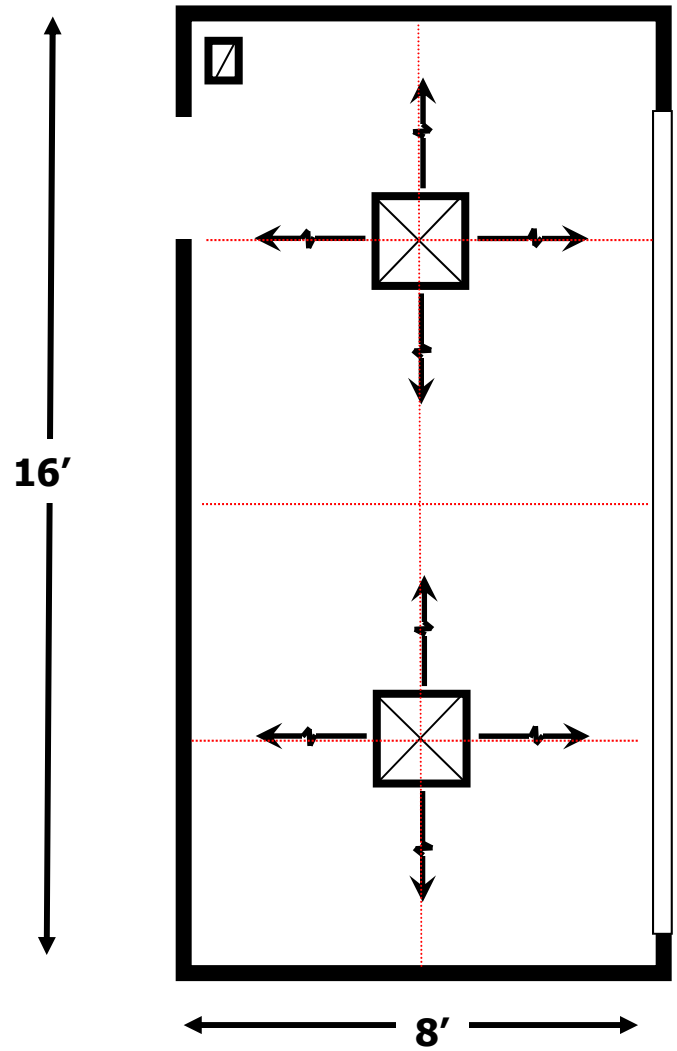
Core Area Square Feet	Nominal Size			Core Vel	400	500	600	700	800	900	1000	1100	1200	1300
				Vel. Press	.010	.016	.022	.031	.040	.050	.062	.075	.090	.105
				Neg. SP	.042	.067	.094	.130	.169	.212	.262	.317	.379	.444
.15	7x4			CFM	60	75	90	105	120	135	150	165	180	195
	6x5			NC	—	—	—	15	20	25	29	33	36	39
.18	8x4	6x6		CFM	72	90	108	126	144	162	180	198	216	234
	7x5			NC	—	—	11	17	22	26	30	34	38	41
.22	10x4	7x6		CFM	88	110	132	154	176	198	220	242	264	286
	8x5			NC	—	—	12	18	23	28	32	36	39	42
.26	12x4	8x6		CFM	104	130	156	182	208	234	260	286	312	338
	10x5			NC	—	—	13	19	24	29	33	37	40	43
.30	14x4			CFM	120	150	180	210	240	270	300	330	360	390
				NC	—	—	14	20	25	30	34	38	41	44
.34	16x4	10x6		CFM	136	170	204	238	272	306	340	374	408	442
	12x5			NC	—	—	15	21	26	31	35	39	42	45
.39	18x4	12x6		CFM	156	195	234	273	312	351	390	429	468	507
	14x5	8x8		NC	—	—	16	22	27	32	36	40	43	46
.46	20x4	14x6		CFM	184	230	276	322	368	414	460	506	552	598
	16x5	10x8		NC	—	10	17	23	29	33	37	41	44	48
.52	24x4	16x6		CFM	208	260	312	364	416	468	520	572	624	676
	18x5			NC	—	11	18	24	29	34	38	42	45	48
.60	28x4	18x6	10x10	CFM	240	300	360	420	480	540	600	660	720	780
	20x5	12x8		NC	—	12	19	25	31	35	39	43	46	50
.69	30x4	20x6	12x10	CFM	276	345	414	483	552	621	690	759	828	897
	24x5	14x8		NC	—	13	20	26	32	36	40	44	47	51
.81	36x4	22x6	14x10	CFM	324	405	486	567	648	729	810	891	972	1053
	28x5	16x8		NC	—	14	21	28	33	37	41	45	49	52
.90	40x4	26x6	16x10	CFM	360	450	540	630	720	810	900	990	1080	1170
	30x5	18x8	12x12	NC	—	15	22	28	34	38	42	46	49	52
1.07	48x4	30x6	14x12	CFM	428	535	642	749	856	963	1070	1177	1284	1391
	36x5	18x10		NC	—	16	24	30	35	39	43	47	51	54

Return Register Layout

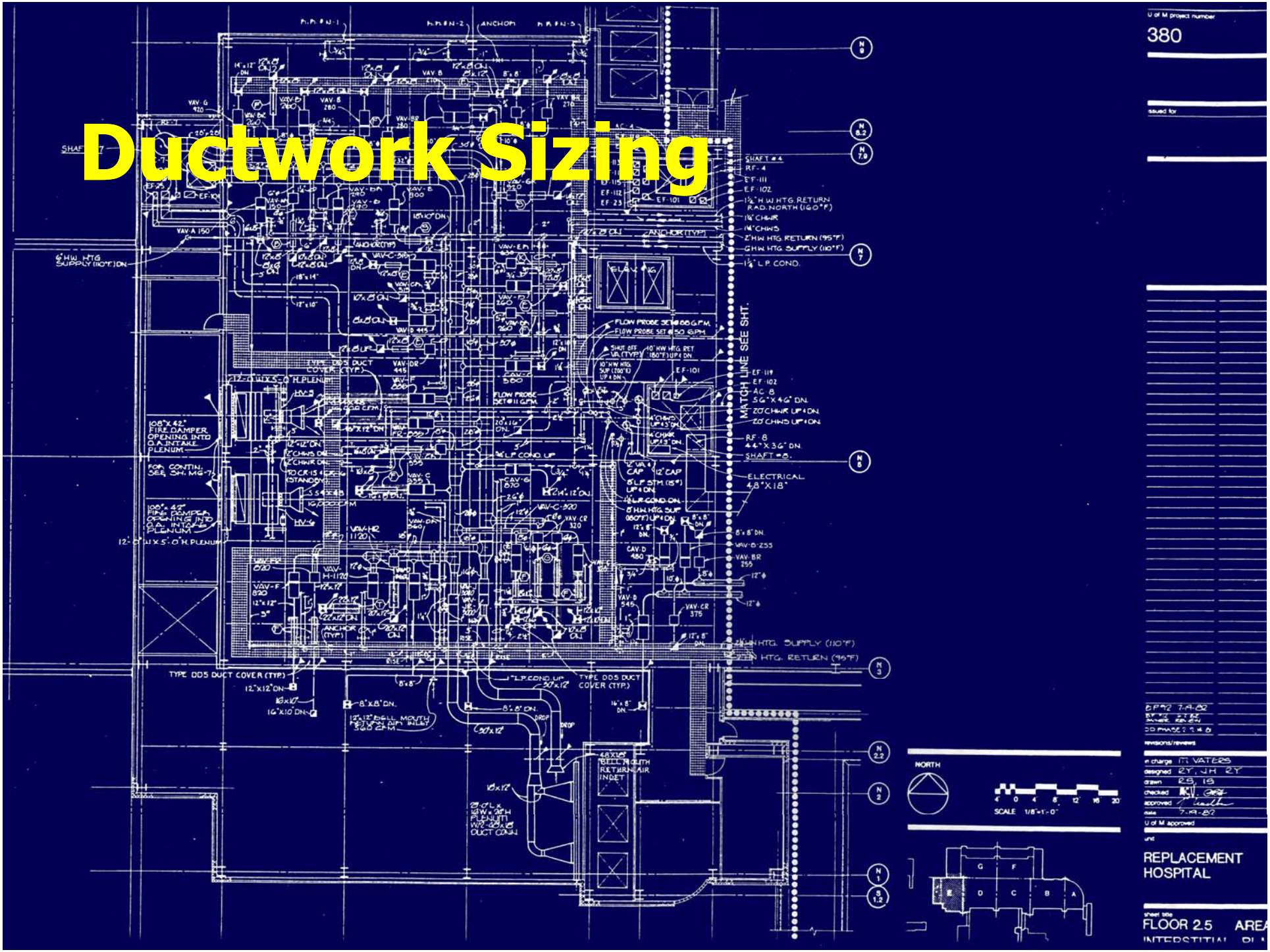
Define Pattern

Supply=350 cfm

Return
1@350=350 cfm
10″ x 8″
NC 27db



Ductwork Sizing



Ductwork Sizing

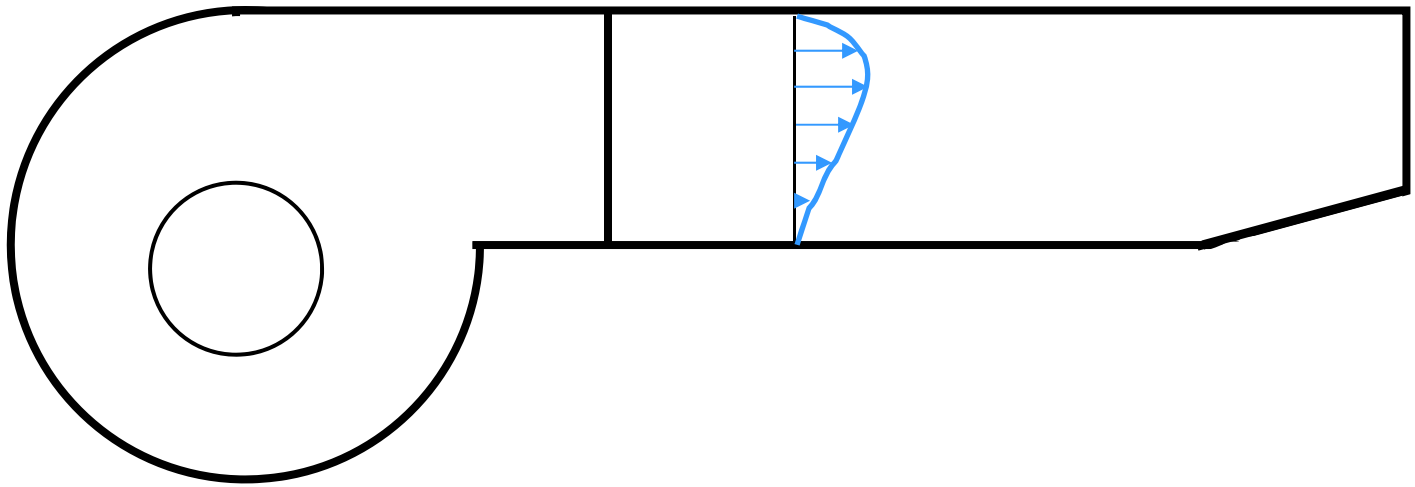
Volume (Q) is a function of cross sectional area (A) and velocity (V)

$$Q=AV$$

however, momentum, friction and turbulence must also be accounted for in the sizing method

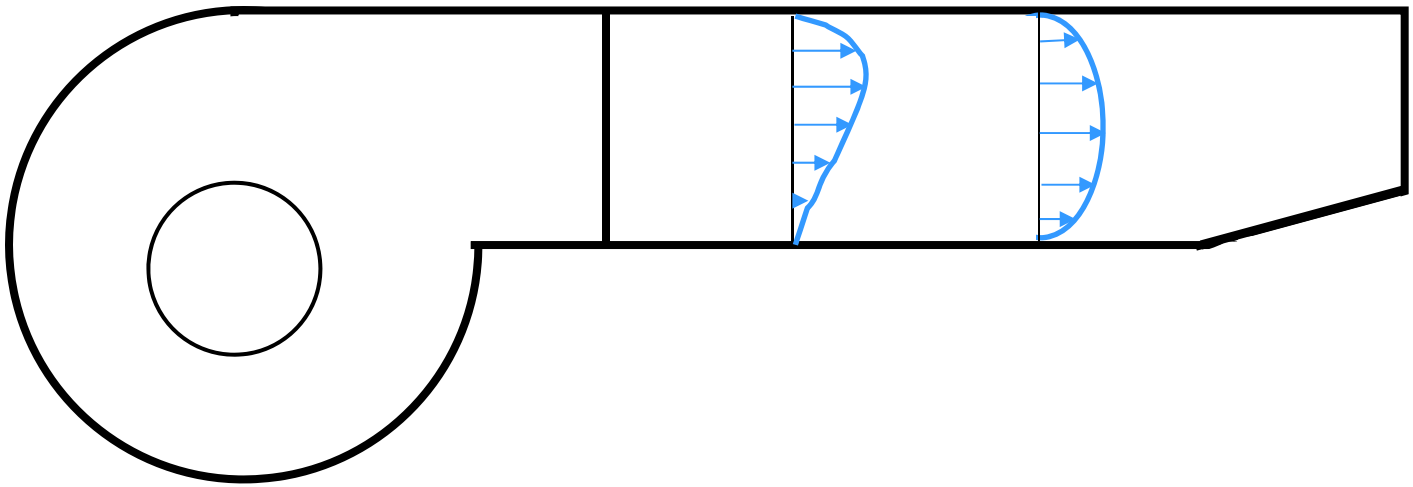
Momentum

As air leaves fan, centrifugal motion creates momentum



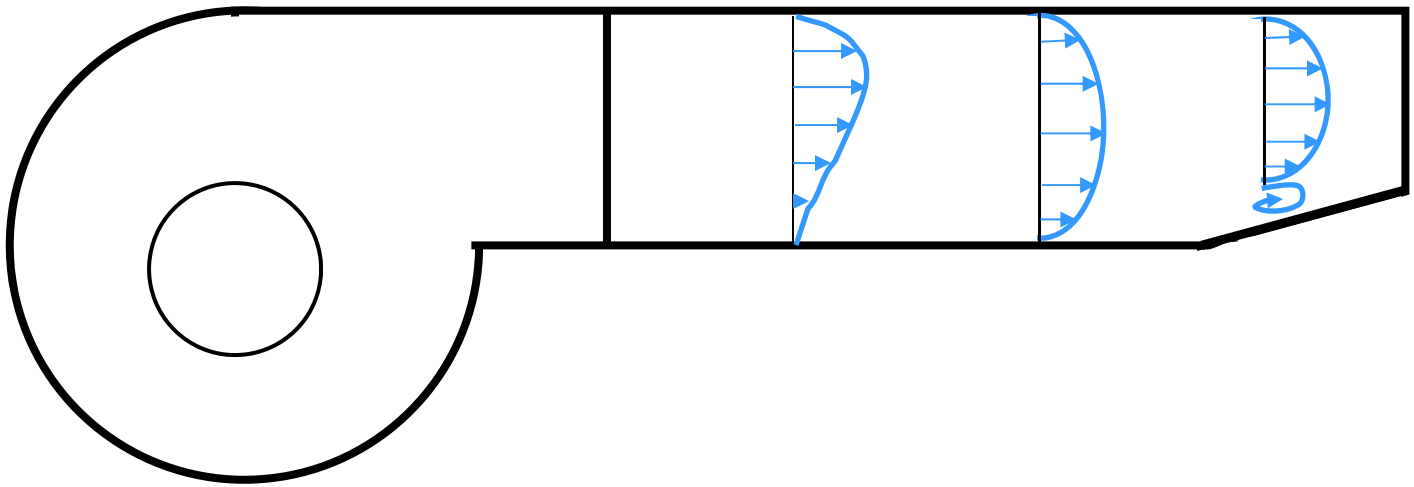
Friction

As air moves along a duct, friction slows the velocity at the edges



Turbulence

As ducts change direction or cross-sectional dimensions, turbulence is created



Static Pressure

Force required to overcome friction and loss of momentum due to turbulence

As air encounters friction or turbulence, static pressure is reduced

Fans add static pressure

Pressure Measurement

Static pressure is measured in inches of force against a water column

Inches-water gauge

Positive pressure pushes air

Negative pressure draws air

Pressure Measurement

Straight ducts have a pressure loss of

"w.g./100'

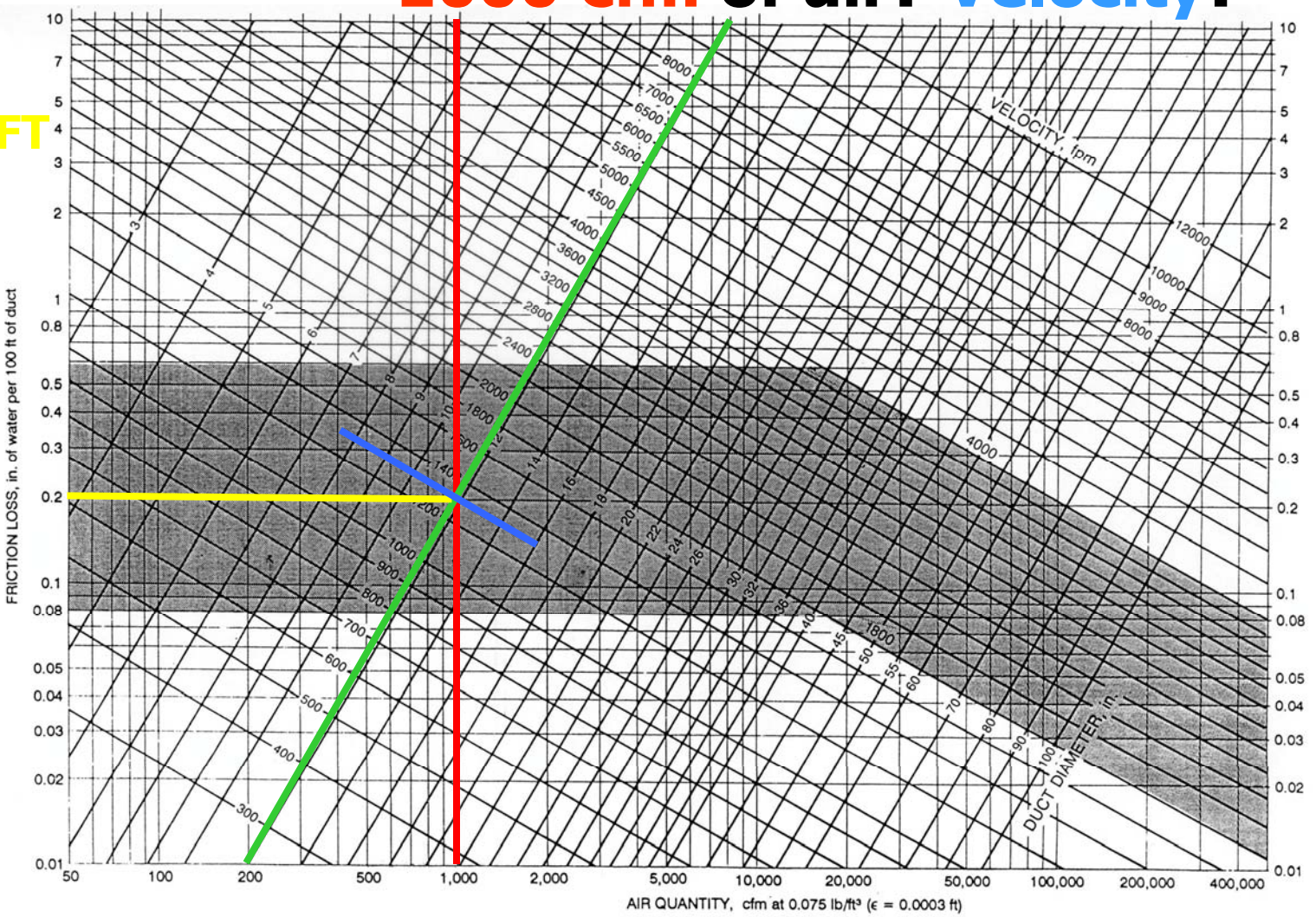
based on diameter and velocity

Friction Loss Chart

What is the pressure loss/100 ft in a 12" diameter duct delivering 1000 cfm of air? Velocity?

0.2"/100 FT

1325 fpm



Equivalent Length

Describes the amount of static pressure lost in a fitting that would be comparable to a length of straight duct

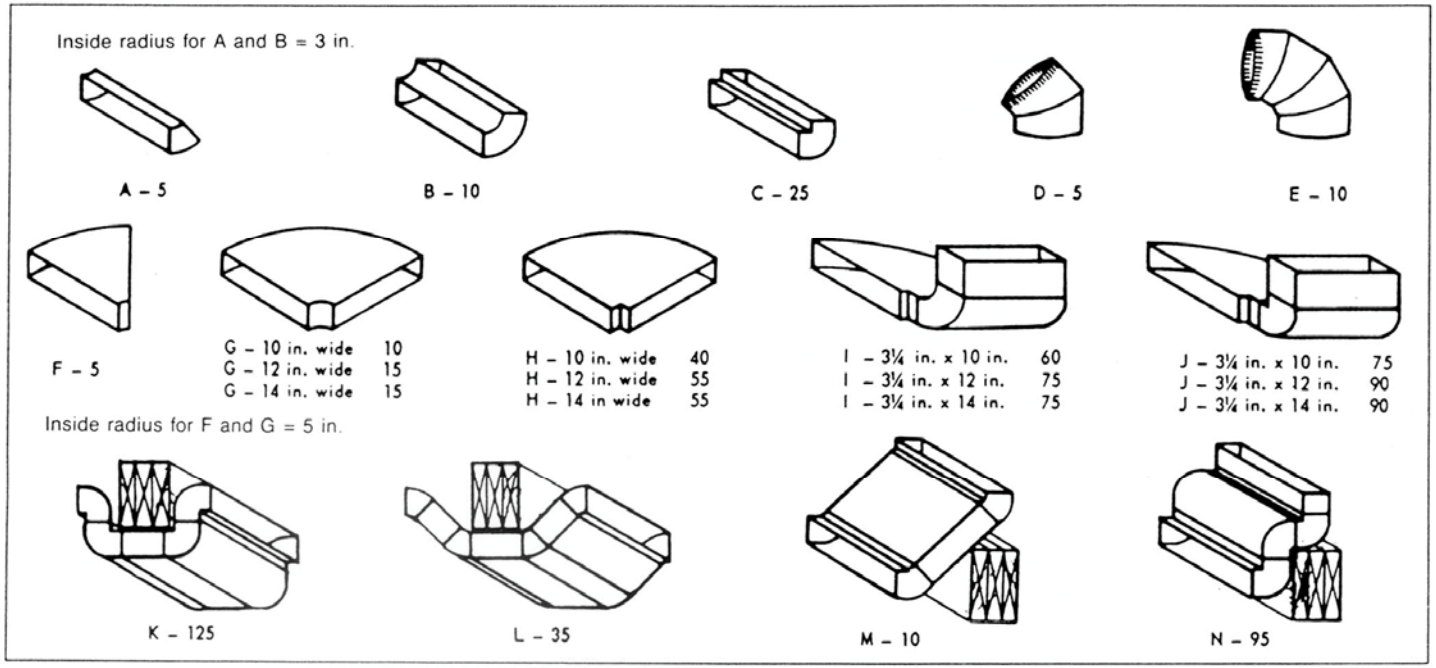


Fig. 12 Equivalent Length in Feet of Angles and Elbows for Branch Ducts (ACCA 1984)

Ductwork Comparison

Round ductwork is the most efficient but requires greater depth

Rectangular ductwork is the least efficient but can be reduced in depth to accommodate smaller clearances

Avoid aspect ratios greater than 5:1

Equal Friction Method

Presumes that friction in ductwork can be balanced to allow uniform friction loss through all branches

Equal Friction Method

1. **Find effective length (EL) of longest run**
2. **Establish allowed static pressure loss/100’**

   $\Delta P = 100(SP)/EL$
3. **Size ducts**
4. **Repeat for each branch**

Note: velocity must be higher in each upstream section

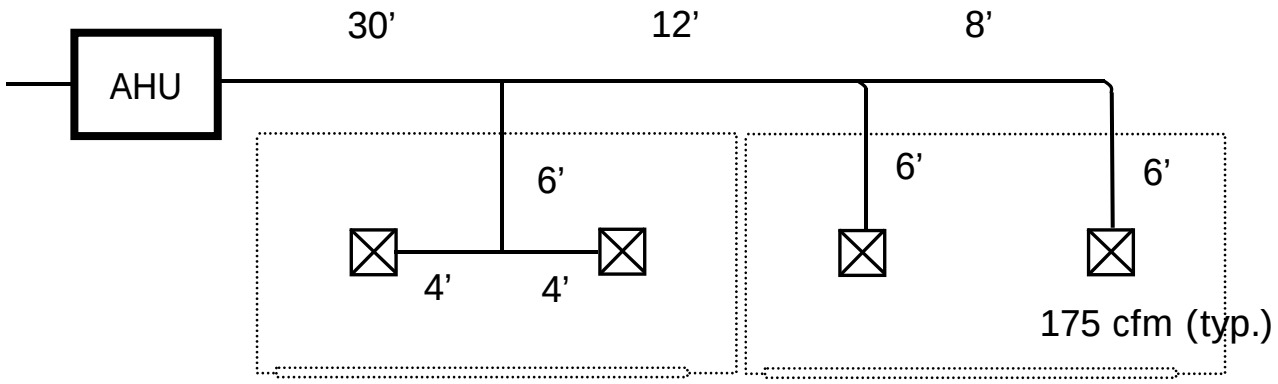
Equal Friction Method Example

Size ductwork serving office diffusers from earlier example

Elbow equivalent length: 10’

Straight fitting equiv. length: 5’

AHU connection: 50’



Equal Friction Method Example

Supply Diffuser pressure loss: 0.038”

Return Register pressure loss: 0.159”

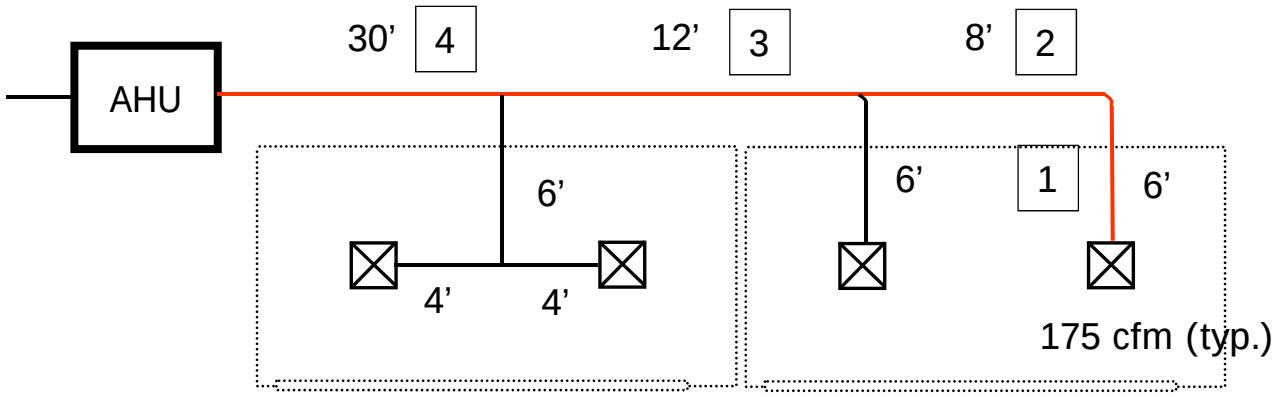
Fan: 0.535”w.g. (75% for supply)

Equal Friction Method

1. Find effective length of longest run

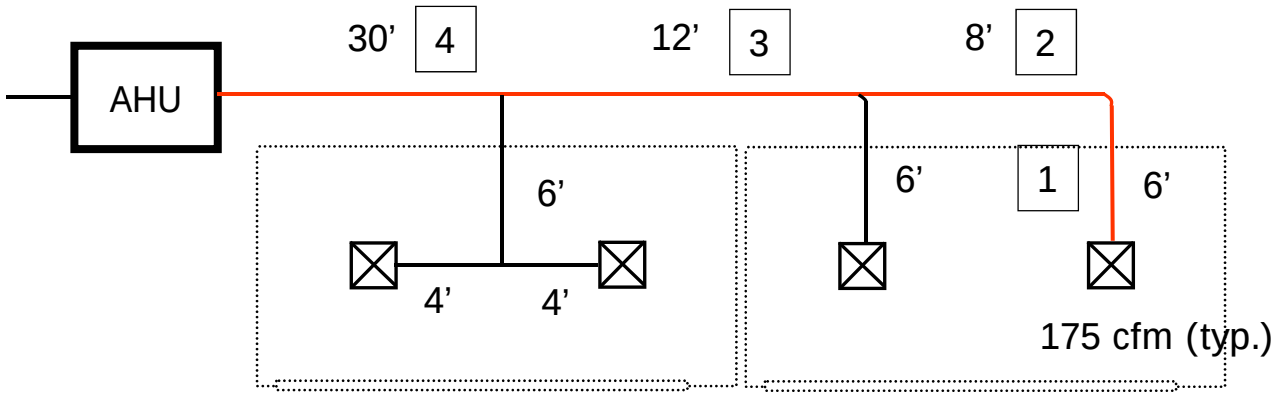
Identify longest run

Label duct sections



Worksheet

Duct Section	Actual Length	Equiv Length	Effective Length	Air Vol.	ΔP "/100'	Duct Diam	Air Velocity
1	6'	10'	16'	175			
2	8'	5'	13'	175			
3	12'	5'	17'	350			
4	30'	50'	80'	700			
	56'	70'	126'				



Equal Friction Method

2. Establish allowed static pressure loss/100′

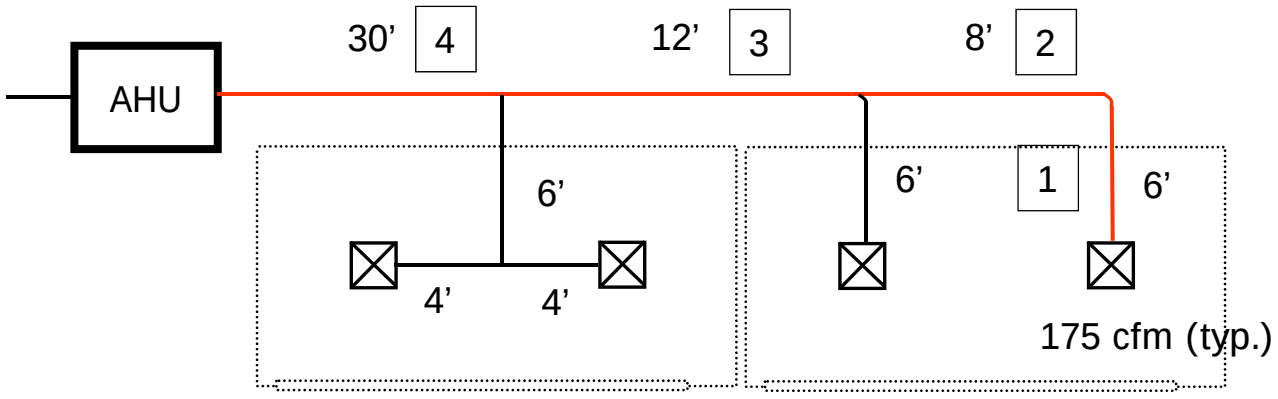
Fan SP:	**0.533″**
-Supply Diff:	**0.038″**
-Return Reg:	**<u>0.159″</u>**
Available:	**0.336″**
x **0.75=**	**0.252″**

ΔP/100′ =100(SP)/EL

= 100(.252)/126= <u>0.2″/100′</u>

Worksheet

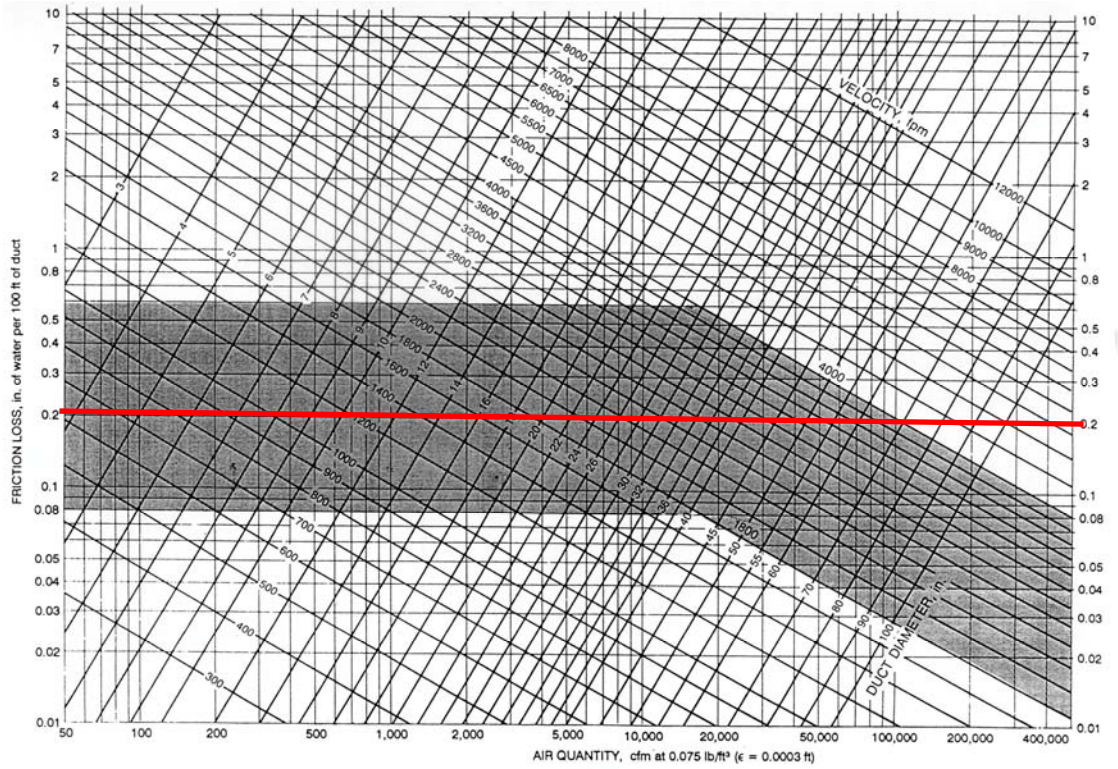
Duct Section	Actual Length	Equiv Length	Effective Length	Air Vol.	ΔP "/100'	Duct Diam	Air Velocity
1	6'	10'	16'	175	0.2		
2	8'	5'	13'	175	0.2		
3	12'	5'	17'	350	0.2		
4	30'	50'	80'	700	0.2		
	56'	70'	126'				



Equal Friction Method

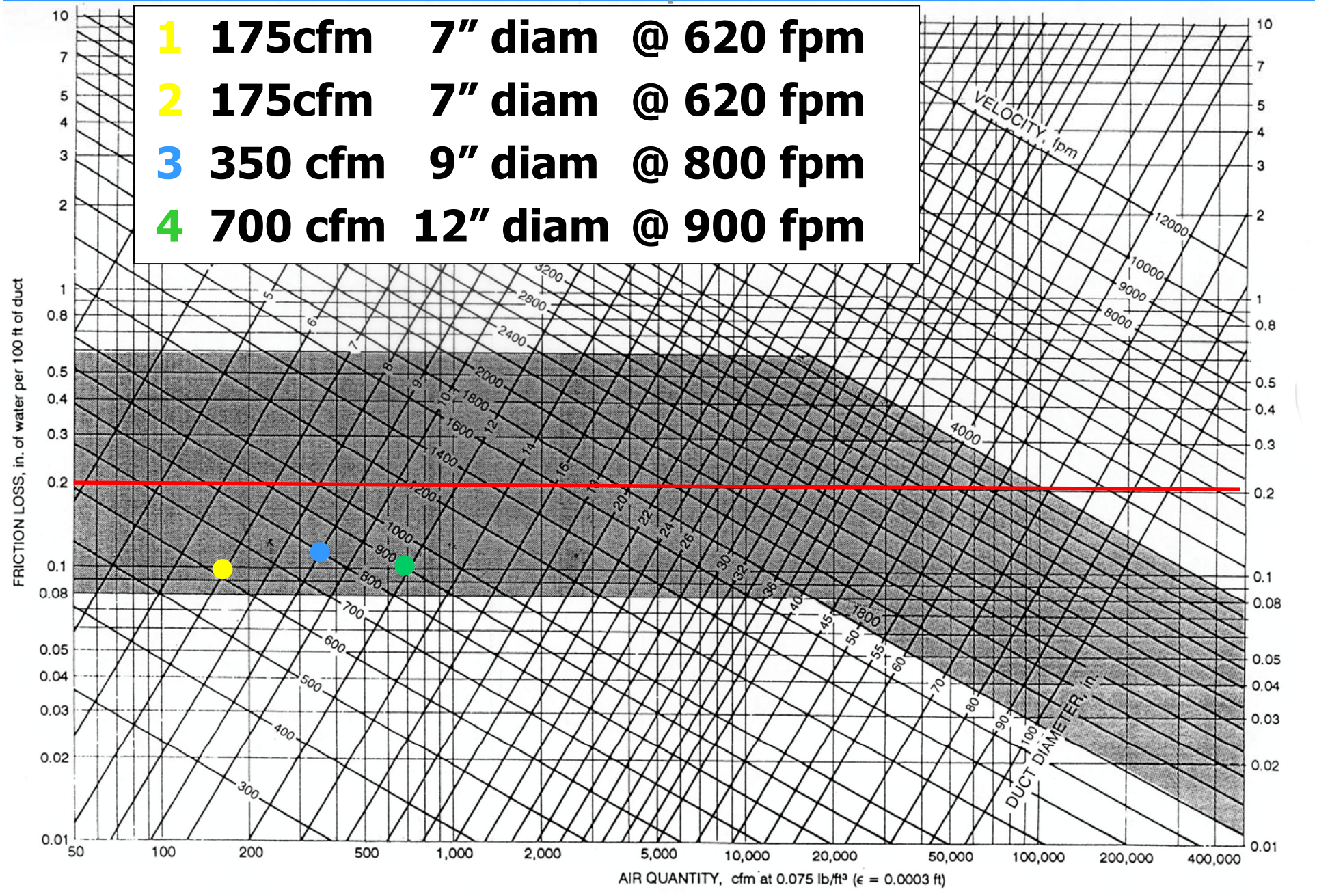
3. Size ducts

RR-6



3. Size ducts

Equal Friction Method



Worksheet

Duct Section	Actual Length	Equiv Length	Effective Length	Air Vol.	ΔP "/100'	Duct Diam	Air Velocity
1	6'	10'	16'	175	0.2	7"	620 fpm
2	8'	5'	13'	175	0.2	7"	620 fpm
3	12'	5'	17'	350	0.2	9"	800 fpm
4	30'	50'	80'	700	0.2	12"	900 fpm
	56'	70'	126'