MCC POWERS
professionals in energy management

AIR MAIN SIZING

Application Eng. Form
AE-15
July, 1979

INTRODUCTION

This Application Engineering Form presents a simplified method for sizing air mains. Undersizing compressed air mains results in improper or poor control functions; oversizing, in excessive material and labor costs.

AIR CAPACITY REQUIREMENTS

Table 1 on page 2 of Technical Instruction Form AC 141-4 Supplement 1 in Section 1 of the Technical Manual lists controls which must be considered when sizing air mains or compressors. Note that the air consumption values for tube sizing are the same as those for air compressor sizing in AC 141-4 Supplement 1 with the exception of the following thermostat types:

TH 182 DN, DNV, HC, DS,
TH 188 HC, TH 832 DN

All values listed for compressor sizing are based on average load conditions. For air main sizing, the thermostat types mentioned above must be assigned an air consumption value of 50 scim. This value is based on the instrument's maximum sustained demand which occurs during a changeover mode from day to night or cooling to heating.

Air consumption for tube sizing includes:

1. Instrument air bleed
2. Tubing and instrument leakage
3. Control cycling (to operate valves and damper motors, etc.)

To properly size compressed air mains, attention must be paid to all devices and equipment through which air must pass to reach the final controller, per Table 1 of Technical Instruction Form AC 141-4, Supplement 1. This includes:

1. Air supply lines (mains)
2. Pressure reducing valves
3. Pressure changeover devices (3-way valve, EP valve, selector switch, etc.)

All of the above must be sized to deliver the required volume of air. Table "A" below lists recommended total allowable pressure drops for various types of supply systems:

NOTE: All air flow rate values listed in this form are expressions of mass flow rate.

Table A - Total Allowable Pressure Drops (TAPD)

Type of Supply System	Recommended Total Allowable Pressure Drop (psi)
Single Pressure Main 18 to 25 psig	3.0
Dual Pressure Main 18 and 25 psig	1.0
High Pressure Main 70 to 100 psig	20.0

Table "B" below lists equivalent lengths of tubing for devices commonly found in series with the air main:

EQUIVALENT TUBING AND FLOW RATES

MCC POWERS EQUIPMENT	PORTS CONNECTED	FLOW RATE (scim) * @18 psig	@25 psig	EQUIVALENT TUBING
RL 243 SW Switching Relay with 1/4" O.D. Barb x 1/8" MPT Fittings	A→D B→D	650 1 000	700 1 100	100 Ft. 1/4" O.D. Copper 100 Ft. 1/4" O.D. Copper
VE 265 EP 3-Way Electro-Pneumatic Valve with 1/4" O.D. Barb x 1/8" MPT Fittings	N.O.→C N.C.→C	1 100 1 000	1 200 1 100	100 Ft. 3/8" O.D. Plastic 100 Ft. 1/4" O.D. Copper
SW 786 Selector Switch with 1/4" O.D. Barb x 1/16" MPT Fittings	1→2 1→3 1→4	1 700 1 700 1 700	1 900 1 900 1 900	100 Ft. 3/8" O.D. Plastic 100 Ft. 3/8" O.D. Plastic 100 Ft. 3/8" O.D. Plastic
SW 786 LC Large Capacity Selector Switch with 3/8" O.D. Barb x 1/8" MPT Fittings	1→2 1→3 1→4	4 500 4 500 4 500	5 200 5 200 5 200	100 Ft. 1/2" O.D. Plastic 100 Ft. 1/2" O.D. Plastic 100 Ft. 1/2" O.D. Plastic
VP 656 U 1/2" 3-Way Mixing Unit Control Valve (C_U = 3.4) with Line Size Fittings	B→C U→C	25 000 25 000	29 000 29 000	100 Ft. 3/4" O.D. Copper 100 Ft. 3/4" O.D. Copper

Table B

*Flow Rate is based on listed supply pressure (18 or 25 psig) and a pressure drop of 1 psi.

AIR MAIN SIZING PROCEDURE

1. Make a simplified schematic layout of the distribution system for each floor. For multistory buildings, include an elevation drawing showing risers and compressor locations.

AIR MAIN SIZING PROCEDURE (Cont'd)

A. Label each tube section for easy reference.
B. Show the air consumption for each "controlling" device (From Table 1 in AC 141-4, Supl. 1).
C. Show the air flow rate (scim) through each section of tube.
D. Indicate the total equivalent length of each section of tube. For example:

   Scale length of tube section (obtained from plans)
 \+ Equivalent length of any device in series with tube section (from Table "B")
 x 1.1 (to allow for fittings, pipe burrs, careless soldering, pipe aging, etc.)
 = Total equivalent length

(Scaled length + equivalent length of device in series) x 1.1 = Total equivalent length

2. From the schematic determine the total equivalent length of the longest tubing run.
3. From Table "A" choose the recommended total allowable pressure drop (TAPD) for the type of system being sized (single pressure, dual pressure, high pressure).
4. Divide the total equivalent length (from step 2 above) by 100 ft. to determine the number "N" of 100 equivalent foot lengths of tubing in the longest run.
5. Calculate the allowable pressure drop per 100 ft. = the design pressure drop (DPD)

   $$DPD = \frac{TAPD \text{ (From step 3)}}{N \text{ (From step 4)}}$$

6. Select tubing sizes from the appropriate graph (Figures 4, 5 or 6). Always size dual pressure air mains on the basis of the smaller supply pressure.
7. Calculate the actual pressure drop for each tube section. This is accomplished by multiplying the pressure drop per 100 ft. for the particular size tubing chosen for each section (from sizing graphs) by the number "N" of 100 ft. equivalent lengths of tubing in the section.
8. Add the actual pressure drop of each section to obtain the total pressure drop in the air main.
9. (Optional) If the total pressure drop found above is considerably less than the recommended total allowable pressure drop (TAPD) for the particular system, a reduction in some tube section sizes may be possible. See precautionary note under "Use of Sizing Graphs" before performing this step.

USE OF SIZING GRAPHS

1. Locate the DPD (calculated in Step 5 of sizing procedure) on the abscissa (horizontal axis) of the appropriate graph.
2. From the DPD point draw a straight vertical line, the entire length of the graph.
3. To size each section of tube, find the intersection of the DPD line (Step 1 & 2 above) and the horizontal air flow line corresponding to the mass flow rate of air (scim) in that section of tube. If the intersection falls between two tube sizes, choose the larger tube size.

This may result in a slight oversizing of the air line, but in most instances this is acceptable. Example 1 shows how to correct for oversizing. Do this only when the savings in material justifies the expenditure of additional engineering time.

AIR MAIN SIZING EXAMPLES

Example 1

A single floor building requires a main feeder to supply the air operated equipment as shown in Figure 1.

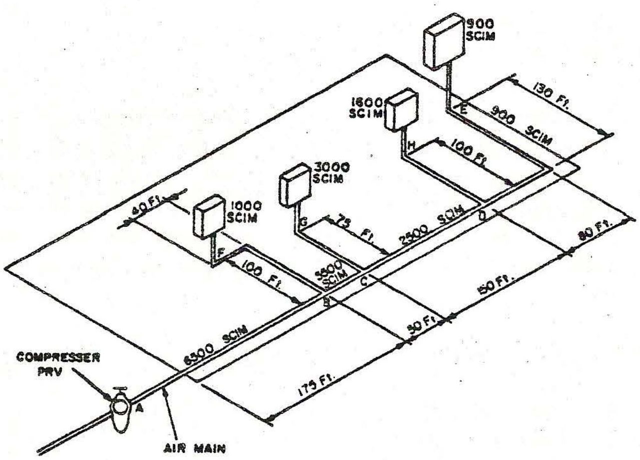


Figure 1

The supply pressure at the PRV is 25 psig, the instrument air consumptions and tube section equivalent lengths are as shown. Follow the steps under "Air Main Sizing Procedure."

Step 1 Is complete per Figure 1.

Step 2 From the schematic, we see that the longest tubing run is AE.

$$AE = 175 \text{ ft.} + 50 \text{ ft.} + 150 \text{ ft.} + 80 \text{ ft.} + 130 \text{ ft.} = 585 \text{ ft.}$$

Step 3 From Table "A" we find that the recommended total allowable pressure drop (TAPD) for a single pressure system is 3.0 psi.

Step 4 The number "N" of hundreds of equivalent feet of tubing in Section AE is 5.85 x 100 ft. = 5.85 hundreds of feet of tube.

Step 5 $$DPD = \frac{TAPD}{N} = \frac{3\text{psi}}{5.85 \times 100 \text{ ft.}} = \frac{.512 \text{ psi}}{100 \text{ ft.}}$$

On Figure Number 5, draw a vertical line at $\frac{.51 \text{ psi}}{100 \text{ ft.}}$

Step 6 Select appropriate tube sizes.
Section AB with an air flow rate of 6500 scim
Select a 5/8" O.D. copper tube.
Section BC with an air flow rate = 5500 scim
Select a 5/8" O.D. copper tube.
Section CD with an air flow rate = 2500 scim
Select a 1/2" O.D. plastic tube.
Section DE with an air flow rate = 900 scim
Select a 3/8" O.D. plastic tube.

Step 7 To find the actual section pressure drop (through tube Section AB, for example) proceed as follows:

A. Locate the actual pressure drop through 100 ft. of that tube size for the air flow rate in that section.

B. Multiply the actual pressure drop found in Step "A" by the equivalent length of the tube section.

For Section AB (175 ft. of 5/8" O.D. copper tube) with an air flow rate of 6500 scim from Figure 5 we see that the actual pressure drop per 100 ft. of tube is .33 psi/100 ft. hence the actual section pressure drop is:

$$\Delta P_{AB} = \frac{.33 \text{ psi}}{100 \text{ ft.}} \times 175 \text{ ft.} = .578 \text{ psi}$$

Similarly by the same reasoning:

$$\Delta P_{BC} = \frac{.33 \text{ psi}}{100 \text{ ft.}} \times 50 \text{ ft.} = .165 \text{ psi}$$

$$\Delta P_{CD} = \frac{.37 \text{ psi}}{100 \text{ ft.}} \times 150 \text{ ft.} = .555 \text{ psi}$$

$$\Delta P_{DE} = \frac{.42 \text{ psi}}{100 \text{ ft.}} \times 210 \text{ ft.} = 210 \text{ ft.} = .882 \text{ psi}$$

Step 8 We now have an actual total pressure drop of 2.18 psi, and the recommended total allowable pressure drop (TAPD) for a single pressure system is 3 psi.

$$\Delta P_{AE} = \Delta P_{AB} + \Delta P_{BC} + \Delta P_{CD} + \Delta P_{DE}$$

$$\Delta P_{AE} = .578 \text{ psi} + .165 \text{ psi} + .555 \text{ psi} + .882 \text{ psi} = 2.18 \text{ psi}$$

Step 9 (Optional) It is usually possible to further optimize the air main size by reducing the size of one or more tube sections. For example, change the 5/8" O.D. copper tube of Section BC to 1/2" O.D.plastic tube.

$$\Delta P_{AE} = .578 \text{ psi} + .375 \text{ psi} + .555 \text{ psi} + .882 \text{ psi} = 2.715 \text{ psi}$$

or reduce the number of tube sizes from three to two (which reduces the variety of fittings required) by using 1/2" O.D. copper tube from A to C and 1/2" O.D. plastic tube from C to E.

$$\Delta P_{AE} = 1.75 \text{ psi} + .375 \text{ psi} + .555 \text{ psi} + .136 \text{ psi} = 2.816 \text{ psi}$$

Sections BF, CG, and DH may be sized as follows: Since the pressure drop from A to B above was determined to be 1.75 psi, the pressure drop from B to F must be 3 psi - 1.75 psi = 1.25 psi or less. From the schematic we see that tube Section BF has a length of 140 equivalent feet. The

$$\text{DPD for BF} = \frac{1.25 \text{ psi}}{1.4 \times 100 \text{ ft.}} = \frac{.893 \text{ psi}}{100 \text{ ft.}}$$

From Figure 5, 3/8" O.D. plastic tube with an air flow rate = 1000 scim will give a pressure drop of .5 psi/100 ft. or $\frac{.5 \text{ psi}}{100 \text{ ft.}} \times 140 \text{ ft.} = .7 \text{ psi}$

Sections CG and DH can be done in a similar manner: For Section CG

$$\Delta P_{AG} = \Delta P_{AB} + \Delta P_{BC} + \Delta P_{CG}$$

$$\Delta P_{AG} = 3 \text{ psi (From Table A)}$$

$$3 \text{ psi} = \Delta P_{AB} + \Delta P_{BC} + \Delta P_{CG}$$

Therefore $\Delta P_{CG} = 3 \text{ psi} - 1.75 \text{ psi} - .375 \text{ psi} = .875 \text{ psi}$ or less.

$$DPD_{CG} = \frac{.875 \text{ psi}}{.75 \times 100 \text{ ft.}} = \frac{1.17 \text{ psi}}{100 \text{ ft.}}$$

From Figure 5, we find that for Section CG, having an air flow rate = 3000 scim (from schematic) and a DPD = 1.17 psi/100 ft. (calculated), 3/8" O.D. copper tube should be used.

Section DH

$$\Delta P_{AH} = \Delta P_{AB} + \Delta P_{BC} + \Delta P_{CD} + \Delta P_{DH}$$

$$\Delta P_{AH} = 3 \text{ psi (From Table A)}$$

$$3 \text{ psi} = \Delta P_{AB} + \Delta P_{BC} + \Delta P_{CD} + \Delta P_{DH}$$

$$3 \text{ psi} = 1.75 \text{ psi} + .375 \text{ psi} + .555 \text{ psi} + \Delta P_{DH}$$

Therefore $\Delta P_{DH} = 3 \text{ psi} - 1.75 - .375 \text{ psi} = .32 \text{ psi}$ or less

AIR MAIN SIZING EXAMPLES (Cont'd)

$$DPD_{DH} = \frac{.32 \text{ psi}}{1 \times 100 \text{ ft.}} = \frac{.32 \text{ psi}}{100 \text{ ft.}}$$

From Figure 5, we find that for Section DH having an air flow rate = 1600 scim (from schematic) and a DPD = .32 psi/100 ft. (calculated). A 1/2" O.D. plastic tube should be used.

Example 2

A high pressure main is to furnish 6,000 scim to a PRV located 750 ft. from the air compressor which furnishes air at 70 psig. What tube size is required?

The equivalent length of tubing = 750 ft. x 1.1 = 825 equivalent feet. From Table "A" the recommended total allowable pressure drop is 20 psi.

$$DPD = \frac{20 \text{ psi}}{8.25 \times 100 \text{ ft.}} = \frac{2.42 \text{ psi}}{100 \text{ ft.}}$$

From Figure 6 for an air flow rate of 6,000 scim and DPD = 2.42 psi/100 ft. Select a 3/8" O.D. copper tube.

Example 3

What is the maximum length of 3/8" O.D. copper tubing capable of transmitting an air flow rate of 2,000 scim with a pressure drop not exceeding 3 psi? Air supply pressure = 18 psig.

From Figure 4 for an air flow rate of 2,000 scim through 3/8" O.D. copper tubing, the pressure drop is found to be 0.7 psi/100 ft. For a pressure drop = 3.0 psi, the maximum length is:

$$L = 3 \cancel{\text{psi}} \times \frac{100 \text{ ft.}}{0.7 \cancel{\text{psi}}} = 428 \text{ ft.}$$

Example 4

An E.P. valve is used in series with a 200 equivalent foot length of 1/4" O.D. plastic tube main. (E.P. piped N.C. → C.) What pressure drop will occur in this main? The air flow rate is 600 scim and the supply pressure is 25 psig.

From Table "B" we find that an E.P. valve piped N.C. → C is equivalent to 100 feet of 1/4" O.D. copper tubing. The total pressure drop in the system is equal to the pressure drop which would occur in a 300 foot system (200 ft. of 1/4" O.D. plastic + 100 ft. of 1/4" O.D. copper tubing) with an air flow rate of 600 scim.

From Figure 5, the following information is obtained.

For 1/4" O.D. plastic tubing with an air flow rate = 600 scim.

$$\frac{\Delta P}{100 \text{ ft.}} = \frac{1.2 \text{ psi}}{100 \text{ ft.}}$$

For 1/4" O.D. copper tubing (equivalent to NC → C E.P. valve) with an air flow rate = 600 scim.

$$\frac{\Delta P}{100 \text{ ft.}} = \frac{0.6 \text{ psi}}{100 \text{ ft.}}$$

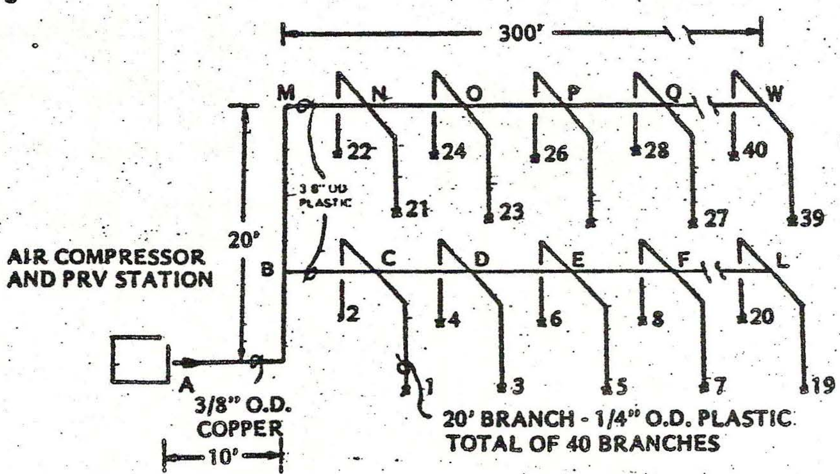
The total pressure drop for the system (tubing + E.P. valve) is:

$$\left(\frac{0.6 \text{ psi}}{100 \text{ ft.}} \times 100 \text{ ft.}\right) + \left(\frac{1.2 \text{ psi}}{100 \text{ ft.}} \times 200 \text{ ft.}\right) = 3.0 \text{ psi}$$

Example 5

A two pressure air main is to furnish 2000 scim of air to a building. With the tubing sizes selected, the system will have a total pressure drop of 0.9 psi at a supply pressure of 18 psig. Will a 3-Way E.P. valve be large enough to handle the 18 to 25 psig switching. From Table "A", the recommended total allowable pressure drop for a dual pressure system is 1 psi. The allowable pressure drop across the E.P. valve is: 1 psi - 0.9 psi = .1 psi. From Table "B" the E.P. has a pressure drop equal to 100 ft. of 1/4" O.D. copper tubing. From Figure 4, with an air flow rate of 2000 scim, the E.P. will have a pressure drop of 5.2 psi; this is much too large a pressure drop, thus the E.P. valve cannot be used for switching. A VP-656U 1/2" 3-Way mixing unit control valve should be used. This valve, with line size fittings, is equivalent to 100 ft. of 3/4" O.D. copper tubing (Table "B") or .02 psi pressure drop with an air flow rate of 2000 scim (Figure 4).

Example 6



Example 6 (Cont'd)

Tube Section	Air Flow (SCIM)	Tube Size (O.D.)	Equivalent Tube Length (ft.)	Pressure Drop (psi/100 ft.)	Actual Pres. Drop (psi)	Accumulative Pressure Drop	
						Tube Section	psi
AB	2000	3/8" Copper	22	.700	.1540	AB	.1540
BM	1000	3/8" Copper	11	.215	.0237	AM	.1777
MN	1000	3/8" Plastic	33	.625	.2063	AN	.3840
NO	900	3/8" Plastic	33	.530	.1749	AO	.5589
OP	800	3/8" Plastic	33	.430	.1419	AP	.7008
PQ	700	3/8" Plastic	33	.340	.1122	AQ	.8130
QR	600	3/8" Plastic	33	.260	.0858	AR	.8988
RS	500	3/8" Plastic	33	.190	.0627	AS	.9615
ST	400	3/8" Plastic	33	.130	.0429	AT	1.004
TU	300	3/8" Plastic	33	.078	.0257	AU	1.030
UV	200	3/8" Plastic	33	.040	.0132	AV	1.043
VW	100	3/8" Plastic	33	.012	.0040	AW	1.047
W 40	50	1/4" Plastic	22	.020	.0044	A40	1.0517

Table C

The system shown in Figure 2 is a two story, 40 room school. A total of 40 TH-182 DN thermostats will be used. The air mains are to be routed as shown. The dual pressure PRV is set at 18 psig (day) and 25 psig (night). Determine the size of the air mains required. From Table 1 of AC-141-4 Supplement 1, each day-night thermostat requires 50 scim of air during changeover. The air main is sized for 2000 scim (40 thermostats times 50 scim per thermostat). The experienced engineer might make the following tubing selection.

Riser A-M . . . . 3/8" O.D. Copper Tubing
Mains M-W and B-L . . . . 3/8" O.D. Plastic Tubing
Supply Lines (i.e. W-40) . . . . 1/4" O.D. Plastic Tubing

To insure adequate capacity the total pressure drop from A to 40 (longest tubing run in system) is determined as decribed in steps 7 and 8 of "AIR MAIN SIZING PROCEDURE". The results are tabulated below. (Table C).

The total pressure drop of the systems longest run is 1.05 psi. This is only slightly larger than the 1 psi recommended total allowable pressure drop for a dual pressure system (From Table "A"). Therefore, this selection of tubing should provide adequate capacity.

Alternate Solution

An alternate solution might be to change sections A-B and BM to 3/8" O.D. plastic tubing. This will give a total pressure drop = 1.40 psi. Since this exceeds the recommended 1 psi pressure drop by a substantial amount, raise the supply pressure to 26 psig.

AIR MAIN SIZING IN HIGH RISE BUILDINGS

In high rise buildings where pneumatic instruments (usually thermostats) are spaced symmetrically around the walls, instruments are supplied air by looping each floor. The loops are fed by one or more mains. This is a convenient means of supplying air which can often be accomplished by using plastic tubing to loop each floor. In office buildings, the location of the instruments is often unknown, and looping with plastic tubing allows a convenient method for tapping into the supply line to locate new thermostats.

The number of thermostats and amount of air flow, together with the type of building construction, will dictate the most feasible and economic method.

Generally, one vertical riser in copper, and loop of plastic tubing, on each floor is recommended. If air consumption per floor is too high to permit the use of 1/2" or 3/8" O.D. plastic tube, a second vertical riser at the opposite end of the building should be used. This divides the air flow of each section of tubing in half.

In buildings using induction units (or any other system which might require an air supply on exterior walls) vertical air mains on each or every other perimeter column should be considered. This approach is sometimes the most economical when looping each floor with plastic tubing is not permissible.

The following points should be given consideration when deciding how to run the main:

1. Location of thermostats
2. Quantity of thermostats per floor
3. Future partitioning or expansion effecting thermostat locations.
4. Ceiling height
5. Have floors already been poured
6. Can plastic tubing be used
7. Construction of building
8. Existing sleeves in floors

AIR MAIN SIZING IN HIGH RISE BUILDINGS (Cont'd)

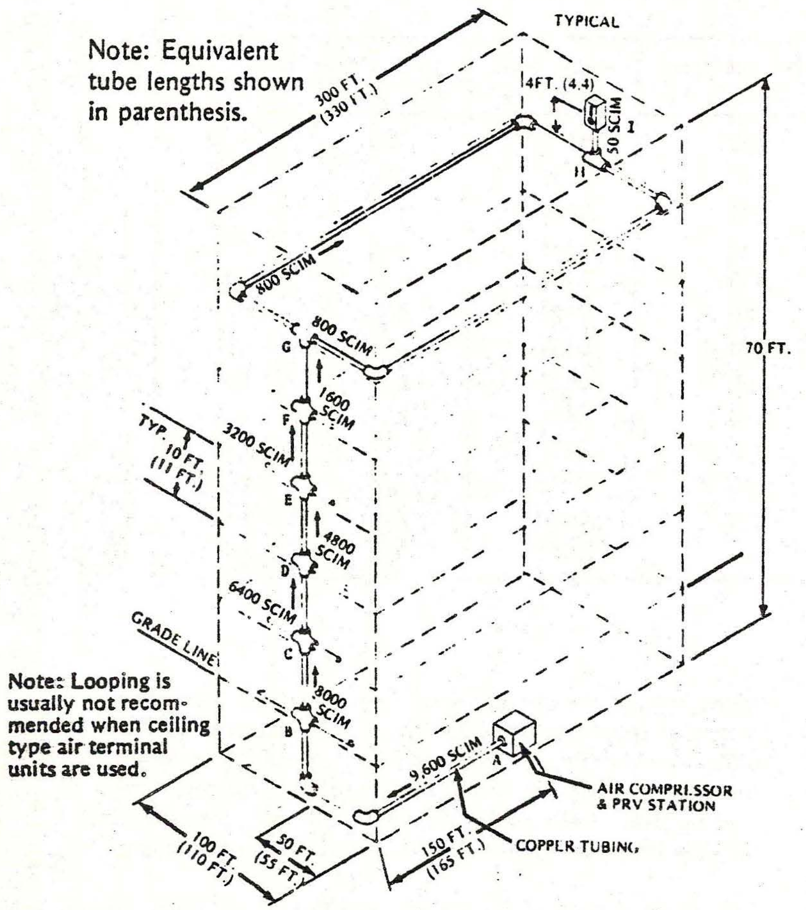


Figure 3

Example 7

Figure 3 shows a typical Hi-Rise building (6 floors) which must be heated and cooled. For clarity only the top floor is shown. H-C thermostats are spaced every 25 ft. (32 thermostats) on each floor. One air main will be used to supply air to all six floors, and must be located as shown. Each floor must be looped with plastic tubing. Determine the copper tube air main and plastic tube loop sizes required.

From Table 1 in AC 141-4 Supplement 1, it is found that each H-C thermostat will require 50 scim during change-over. The total compressed air requirement during change-over is:

6 x 32 H-C x 50 scim = 9,6000 scim

*Note that this air flow rate does not determine compressor size. From Figure 3, the longest tube run is from A to I and has an actual length equal to:

AI = 150 ft. + 50 ft. + 6 (10) ft. + 50 ft. + 300 ft. + 50 ft. + 4 ft. = 664 ft.

To account for fittings, burs, etc. the equivalent length is calculated and equals:

actual (scale) length x 1.1
664 ft. x 1.1 = 730 ft.

From Table "A" the recommended total allowable pressure drop (TAPD) for a dual pressure system = 1.0 psi. The DPD for this system =

$$\frac{1 \text{ psi}}{7.30 \times 100 \text{ ft.}} = \frac{.14 \text{ psi}}{100 \text{ ft.}}$$

Plot the DPD on Figure 4. From Figure 4 select copper tubing sizes for sections AB, BC, CD, DE, EF and FG. Similarly select plastic tubing for the top floor (sections GH and HI) since this was included in the longest tubing run. Using calculations similar to example 1, results are tabulated in Table "D". Since only 20 ft. of 3/4" O.D. copper tubing, 10 ft. of 5/8" O.D. copper tubing, and 10 ft. of 1/2" O.D. copper tubing are used on the entire job, and since the accumulative pressure drop = .95 psi < 1.0 psi, change sections CD, DE, and FG to 5/8" O.D. copper tubing. Trial 2 in Table "D" illustrates the results of this change. This change reduced the number of different types of tubing and fittings from 6 to 4 or a 30% reduction in variety.

TRIAL	TUBE SECTION	AIR FLOW (SCIM)	TUBE SIZE (O.D.)	EQUIV. TUBE LENGTH (Ft.)	PRESSURE DROP (psi/100 Ft.)	ACTUAL PRES. DROP (psi)	ACCUMULATIVE PRES. DROP	
							TUBE SECTION	psi
1	AB	9,600	7/8" COPPER	231	.135	.3119	AB	.3119
	BC	8,000	7/8" COPPER	11	.098	.0108	AC	.3227
	CD	6,400	3/4" COPPER	11	.145	.0160	AD	.3387
	DE	4,800	3/4" COPPER	11	.088	.0097	AE	.3484
	EF	3,200	5/8" COPPER	11	.113	.0124	AF	.3608
	FG	1,600	1/2" COPPER	11	.11	.0121	AG	.3729
	GH	400*	3/8" PLASTIC	440	.13	.5723	AH	.9449
	HI	50	1/4" PLASTIC	4.4	.02	.0009	AI	.9458
2	AB	9,600	7/8" COPPER	231	.135	.3119	AB	.3119
	BC	8,000	7/8" COPPER	11	.098	.0108	AC	.3227
	CD	6,400	5/8" COPPER	11	.380	.0418	AD	.3645
	DE	4,800	5/8" COPPER	11	.230	.0253	AE	.3898
	EF	3,200	5/8" COPPER	11	.110	.0121	AF	.4019
	FG	1,600	5/8" COPPER	11	.034	.0037	AG	.4056
	GH	400*	3/8" PLASTIC	440	.130	.5720	AH	.9776
	HI	50	1/4" PLASTIC	4.4	.02	.0009	AI	.9785

* 800 SCIM does not flow through entire length of GH; use 400 SCIM as average flow. Since the last floor can safely use 3/8" O.D. plastic tube, use on preceding floors also.

Table D

AIR FLOW RATE VS. PRESSURE DROP
FOR
COPPER & PLASTIC TUBING
SUPPLY AIR - 18 PSIG @75°F

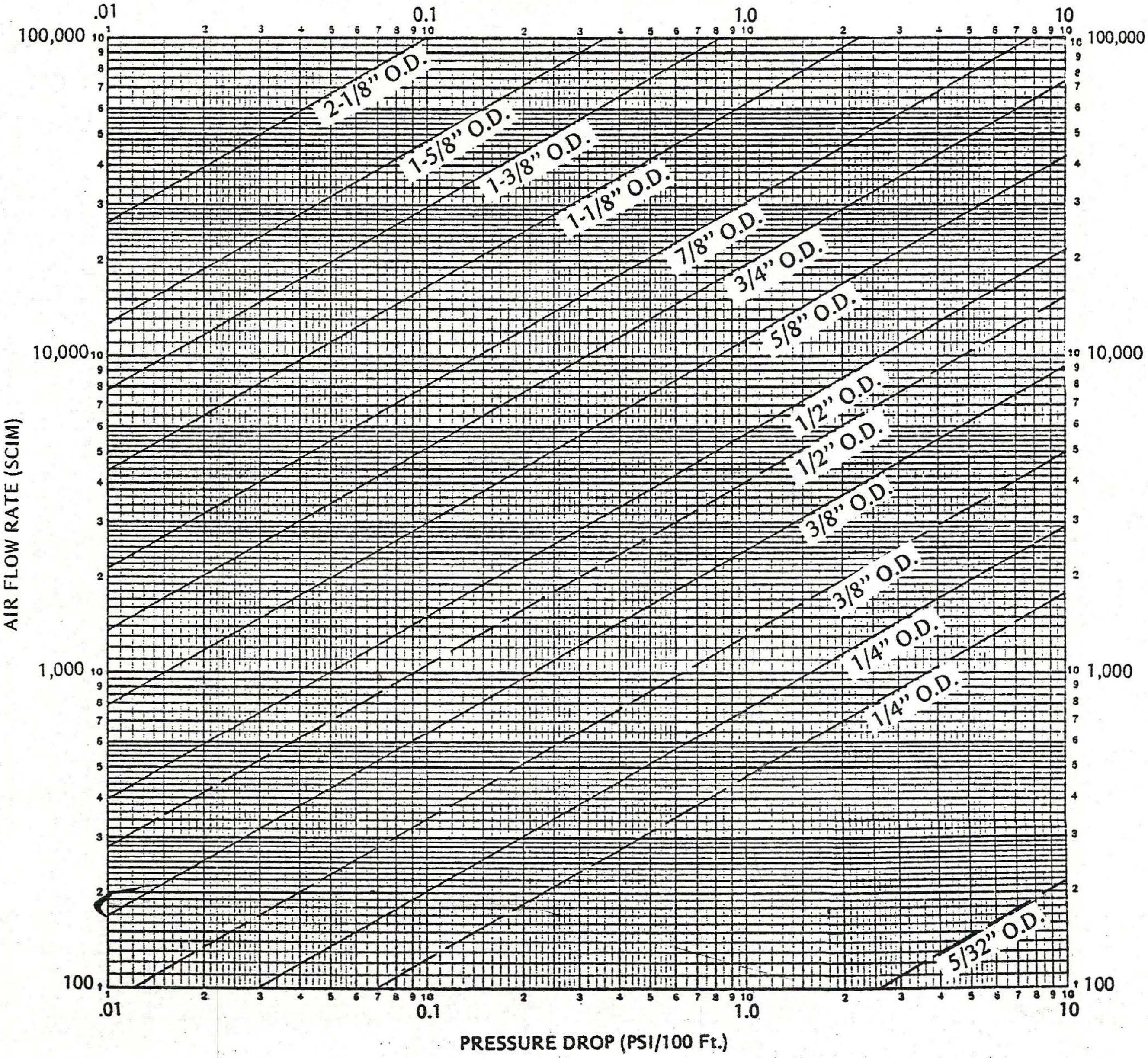


Figure 4

LEGEND

COPPER ————

PLASTIC — — —

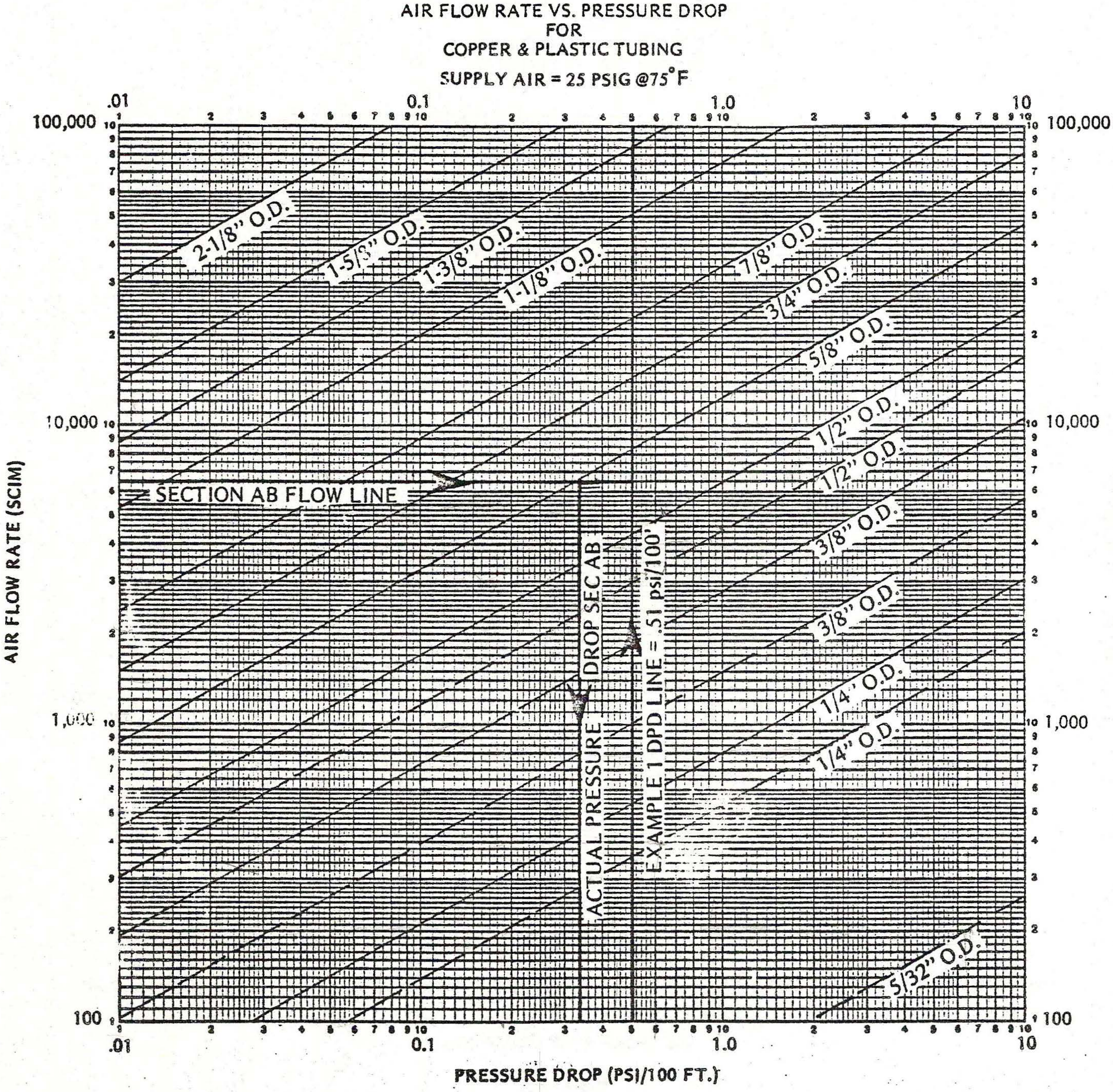


Figure 5

LEGEND

COPPER ___________
PLASTIC ___ ___ _

AIR FLOW RATE VS. PRESSURE DROP
FOR
COPPER & PLASTIC TUBING

SUPPLY AIR - 70 PSIG @ 75°F

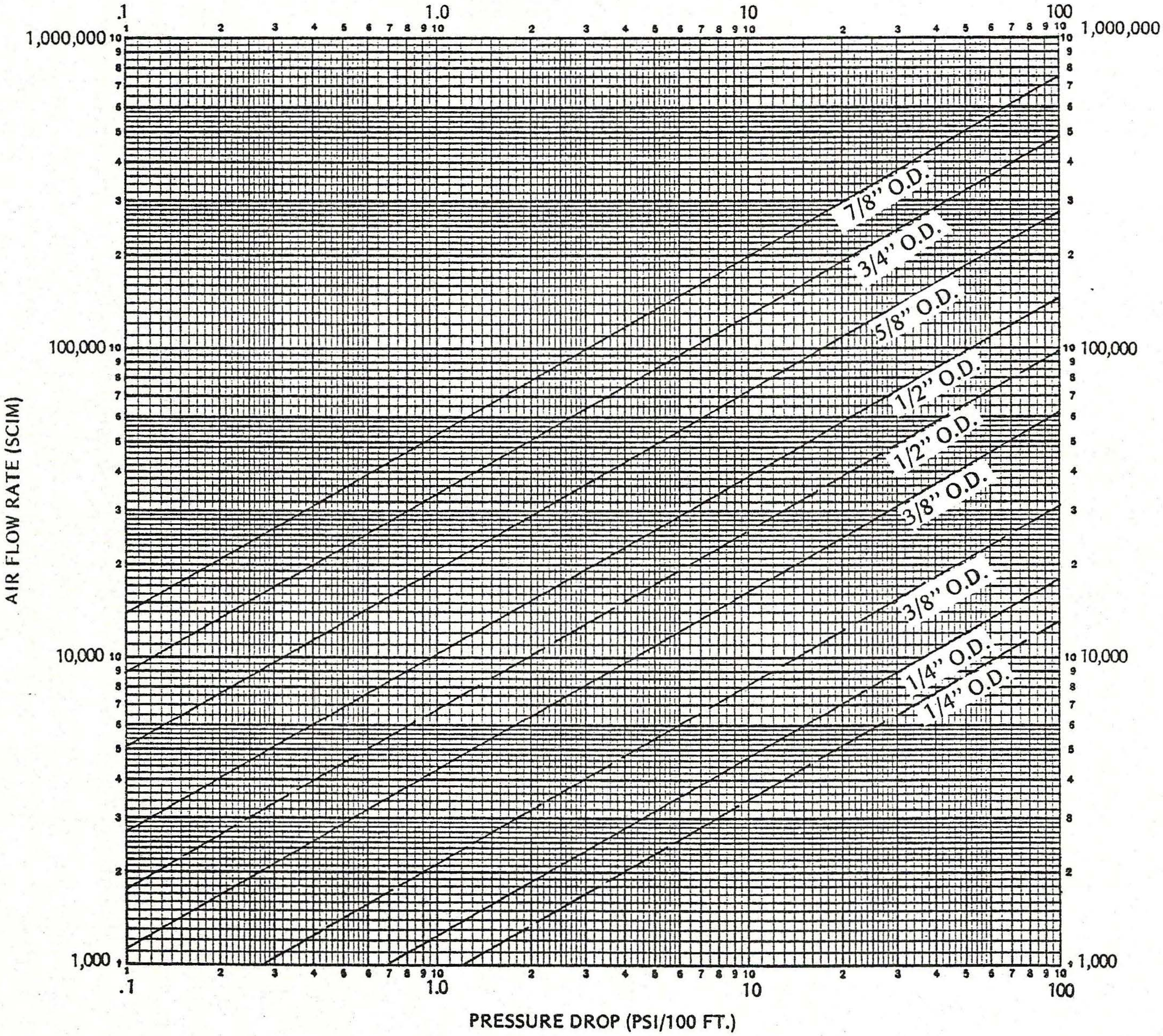


Figure 6

LEGEND

COPPER ————
PLASTIC — — —

GENERAL RULES FOR USING 5/32 in. O.D. TUBING

Response and Accuracy

Control system accuracy and stability depends on accurate reproduction of pressure signals and speed of response of the actuated device. The following basic rules apply:

Speed of Response:

Non-Relay instruments (low volume output) - Speed of response depends on the volume **on** the output of the instrument (output line and actuator). **Small tubing** has less volume and can be an **asset**.

Relay instruments (high volume output) -The volume of the tubing is small compared to the output volume capacity of the controller. However, the pressure drops (resistance to flow) associated with small tubing can cause time delays. Long length of **small tubing** will be a **detriment**.

Accuracy:

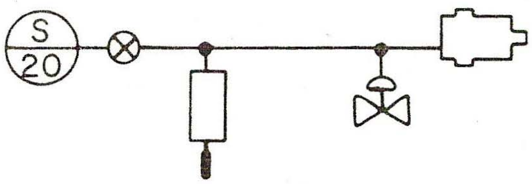
Errors in reproduction of pressures between two locations in a system are caused by the pressure drop produced by flow within the line. Where accuracy is important, **lines experiencing constant flow** should be kept to a **minimum in length and large in diameter**. (25 feet of 5/32 in. tubing will produce a transmission error of 3F° with a 200F° span transmitter.)

USE OF 5/32 in. O.D. TUBING

CONTROL APPLICATIONS

Low Volume Output
Devices with Restricted Supply

T-5210, T-3610, H-3610
T-4100, etc.
C-5230, etc.

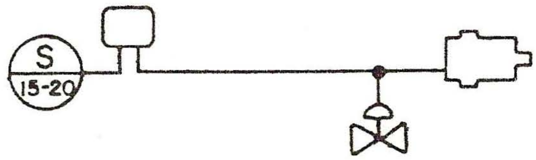


Speed of response depends on filling the volume of the output line and the actuator, 5/32 in. tubing has less volume.

RULE: 5/32 in. O.D. TUBING SHOULD ALWAYS BE USED.

Dual Temperature

T-4502, T-4752, etc.

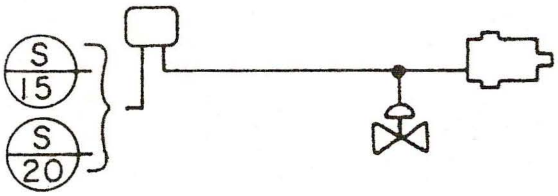


All basic rules of accuracy and speed of response apply. However, another problem exists: A pressure drop in the supply line can cause dual instruments to cycle on switchover.

RULE: USE 5/32 in. O.D. TUBING ON ALL CONTROL LINES. UP TO 15 ft. OF 5/32 in. O.D. TUBING CAN BE USED ON THE SUPPLY LINE IF SUPPLY MAIN IS PROPERLY SIZED IN ACCORDANCE WITH SECTION A OF THE ENGINEERING DATA BOOK.

Intermediate Volume Output
Instruments

Single temperature T-4000 series room stats and auxiliary devices such as cumulators, etc.



At 20 PSIG supply

Tubing size has little effect even up to lengths of 150 ft. total (supply and control lines).

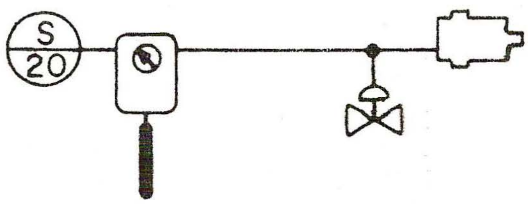
At 15 PSIG supply

A lower differential across the instrument results in less potential to produce flow. When lengths exceed 50 ft., 5/32 in. tubing begins to affect speed of response.

RULE: 5/32 in. O.D. TUBING CAN BE USED FOR STANDARD ROOM CONTROL APPLICATIONS.

High Volume Output Instruments

T-8000, T-9000, etc.



These devices are usually used where speed of response can be critical (coil discharge, etc.).

Line length up to 50 ft. total (supply and control lines).
Tubing size makes little difference.

Line lengths over 75 ft.

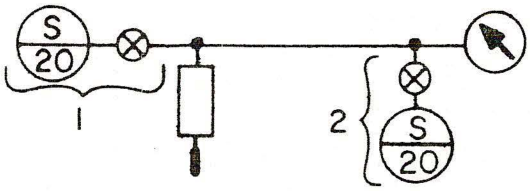
5/32 in. tubing can decrease the speed of response of a pressure change at the actuator by a factor of 3.

RULE: IF SPEED OF RESPONSE IS IMPORTANT TO GOOD CONTROL, USE 1/4 in. O.D. TUBING. DO NOT EXCEED 50 ft. OF 5/32 in. O.D. TUBING.

TRANSMISSION APPLICATIONS

Low Volume Output Devices

T-5210, P-5210, H-5210, etc.

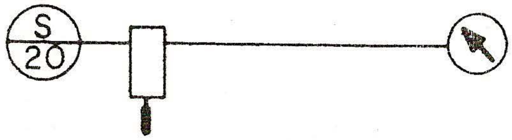


RULE 1: IF RESTRICTOR IS LOCATED AT THE TRANSMITTER AND THE LINE IS DEAD-ENDED, 5/32 in. O.D. TUBING **SHOULD BE USED.**

RULE 2: IF RESTRICTOR IS LOCATED AT THE RECEIVER CONTROLLER, OR OVER 25 ft. FROM THE TRANSMITTER, 1/4 in. O.D. TUBING **SHOULD BE USED.**

High Volume Output Devices

T-5200, T-5220, etc.



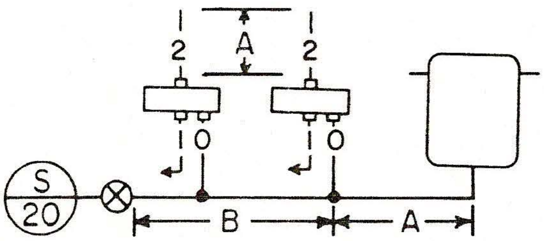
In these applications, high volume output instruments feed small volume dead-ended service (not an actuator), flow capacity is not a problem — just pressure drop.

RULE: UNDER 50 ft., 5/32 in. O.D. TUBING CAN BE USED. OVER 50 ft., 1/4 in. D.O. TUBING WILL PROVIDE SLIGHTLY FASTER RESPONSE.

PRESSURE SELECTION

Low Volume Output Device

C-5226s



Rules that apply to low capacity transmission apply to pressure selection:

A) 5/32 in. O.D. tubing should be used on all dead-end lines.

B) 1/4 in. O.D. tubing should be used for lines experiencing continuous flow.

MCC POWERS EQUIPMENT	INSTRUMENT QUANTITY		COMPRESSOR AIR USAGE (SCIM)		COLUMN "A"
THERMOSTATS & HYGROSTATS					
Powerstar (TH 180D, R, P & B)	–	x	20	=	
(TH 182 DN, DNV, HC, DS)*	–	x	25	=	
(TH 182)—Free Energy Band	–	x	40	=	
TH 192 S (1-Pipe)	–	x	25	=	
TH 192 S (2-Pipe)	–	x	20	=	
TH 192 HC*	–	x	25	=	
TH 194 HC*	–	x	25	=	
TH 192 DN, DNV*	–	x	25	=	
TH 194 DN, DNV*	–	x	25	=	
TH 193 HC (Dual 1-Pipe)	–	x	50	=	
TH 193 HC (Dual 2-Pipe)	–	x	40	=	
TH 193 HC Hesitation	–	x	40	=	
D-Room	–	x	10	=	
D-Room—Day/Night*	–	x	10	=	
Accritem (Domestic Hot Water)	–	x	200	=	
Accritem (Bleed Screw Open 1/4 to 1/2 turns)	–	x	500	=	
Limitem	–	x	15	=	
HU 186 Hygrostat (Room and Duct)	–	x	20	=	
TH 188 Unit Mtd. (HC, w/40 SCIM restr.)*	–	x	45	=	
D.A. w/40 SCIM restr.	–	x	40	=	
R.A. w/20 SCIM restr.	–	x	25	=	
Pneumatic High or Low Temperature Detection Thermostat					
Normal state (for compressor sizing)	–	x	10	=	
Alarm state (for air main sizing)	–	x	40	=	
TRANSMITTERS					
Series 200 Temperature	–	x	25	=	
Powerstar Series (TT 184, HT 186, PT 187, PT 141)	–	x	35	=	
Velocity Pressure VT 141	–	x	30	=	
POSITION SWITCH					
SW 151 (1-Pipe)	–	x	35	=	
RELAYS					
RL 243 MP, BR, Analog & Positive	–	x	35	=	
RL 147 Positive Positioning Relay	–	x	40	=	
RL 243 Signal Selector Relay	–	x	20	=	
RL 243 EC Enthalpy Comparator (Transmitters not included)	–	x	40	=	
SW 269 Static Pressure Switch	–	x	30	=	
CONTROLLERS					
PR 269 Static Pressure & Liquid Level Controller	–	x	25	=	
Series 200 Temperature Pressure, RC & All Submasters	–	x	35	=	
PR 378DP Differential Pressure	–	x	50	=	
Series 101 Temperature (One Pen)	–	x	35	=	
Series 101 Temperature (Two Pen)	–	x	70	=	
RC 195 Receiver Controller (Transmitters not included)	–	x	60	=	
MISCELLANEOUS					
Moore Positioner @ 60 PSIG	–	x	1,200	=	
Aspirator Wall Box Nozzle (Less Thermostat)	–	x	25	=	
VAV Box Velocity Reset Controller (26 to 50 SCIM. See AB 287, Sec. 32, Appl. Man.)	–	x		=	
S600 Pneu. Analog Out. (AO-P) (CPA APPL)	–	x	15	=	
S600 Pneu. Analog Out. (AO-P) (DDC APPL)	–	x	30	=	
Additional purchased items for this installation			Estimated Usage		
__________	–	x		=	
__________	–	x		=	
			Sub-total		______
For desicant dryer multiply by 1.25 Total Continuous Air Usage =					______
To Calculate Compressor Size: Total Continuous Air Usage X 100 / % Compressor Duty				=	______
Select compressor from page 1 which will provide this air quantity.					

Table 1

*When this table is used for sizing air mains, two pressure thermostats (TH 182 HC DN, DNV, DS, TH 188 HC, TH 832 DN) must be sized for 50 SCIM. TH 192 two pressure thermostats must be sized for 40 SCIM. This is the nominal peak flow required during changeover. See AE-15 "Air Main Sizing".

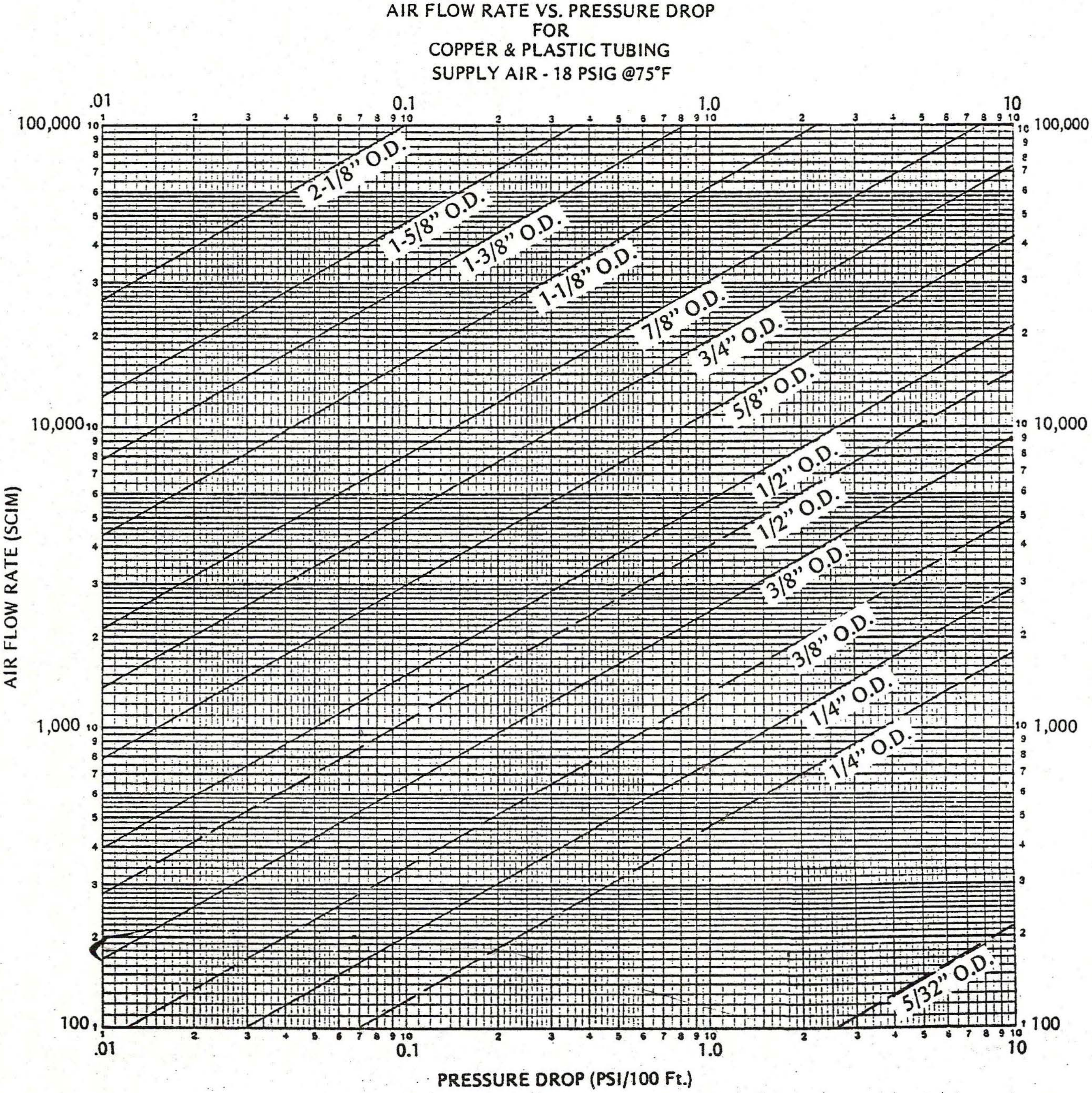


Figure 4

LEGEND

COPPER ————

PLASTIC — — —

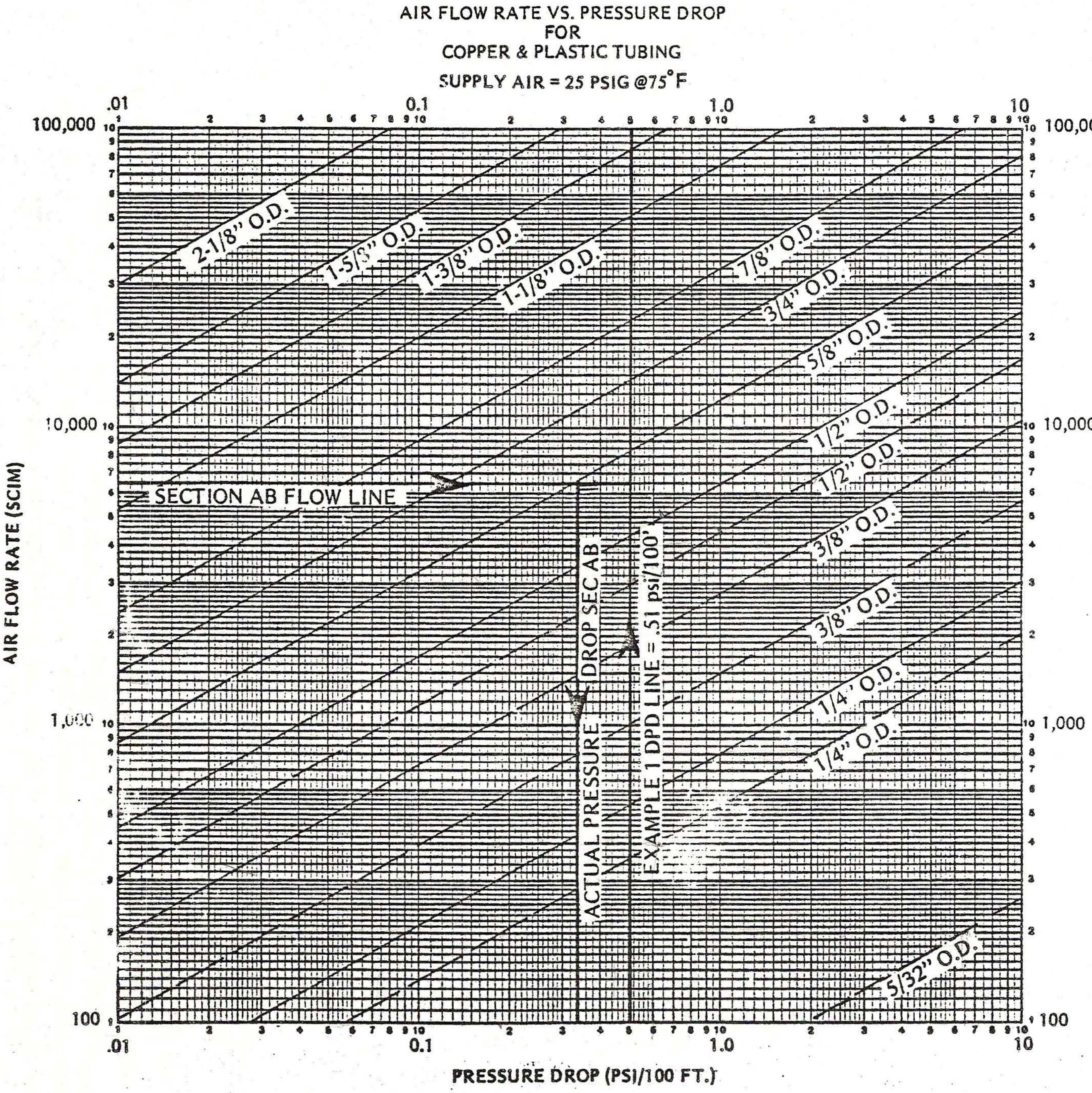


Figure 5

LEGEND

COPPER ————————
PLASTIC —— —— —

AIR FLOW RATE VS. PRESSURE DROP
FOR
COPPER & PLASTIC TUBING

SUPPLY AIR - 70 PSIG @ 75°F

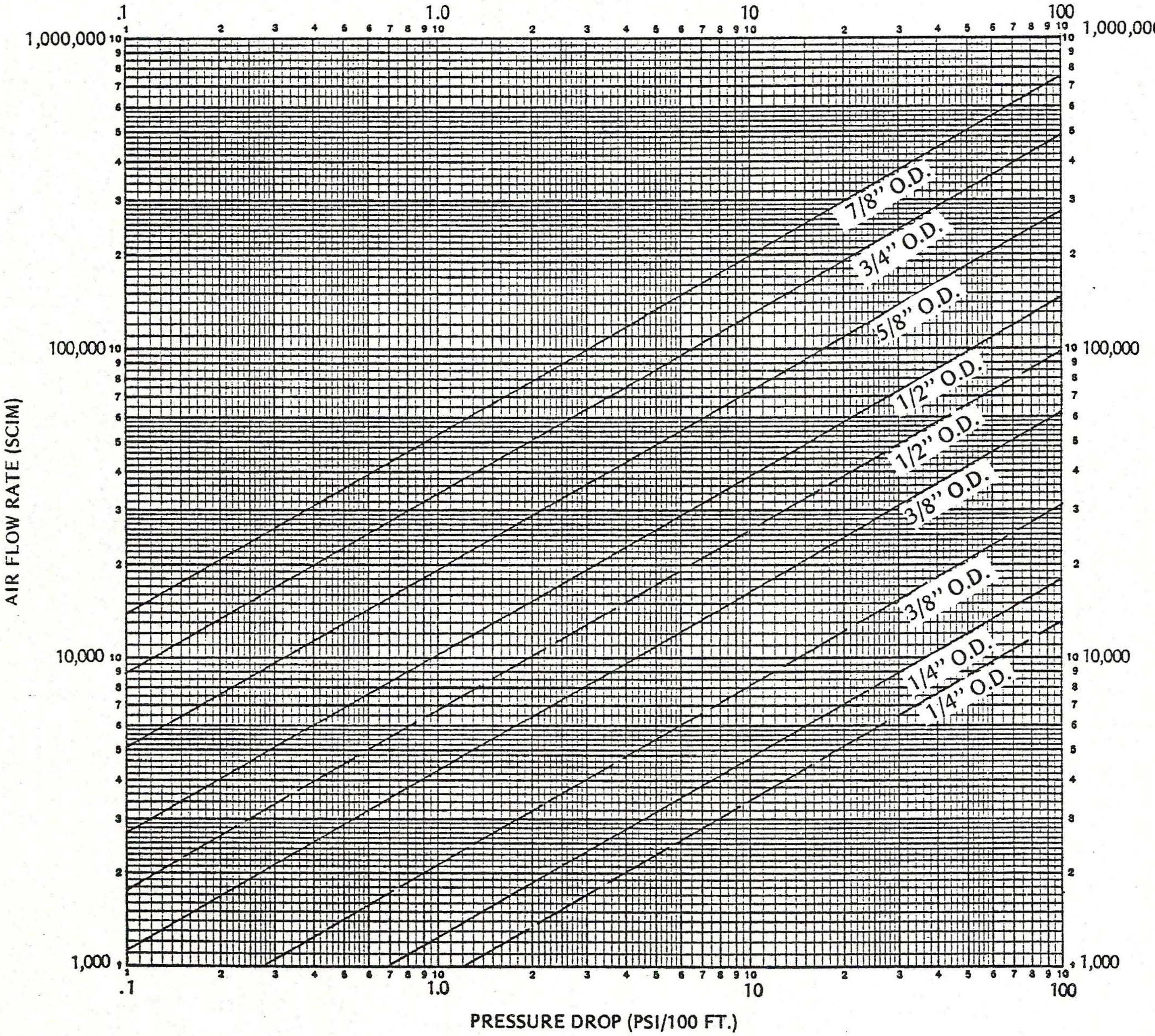


Figure 6

LEGEND

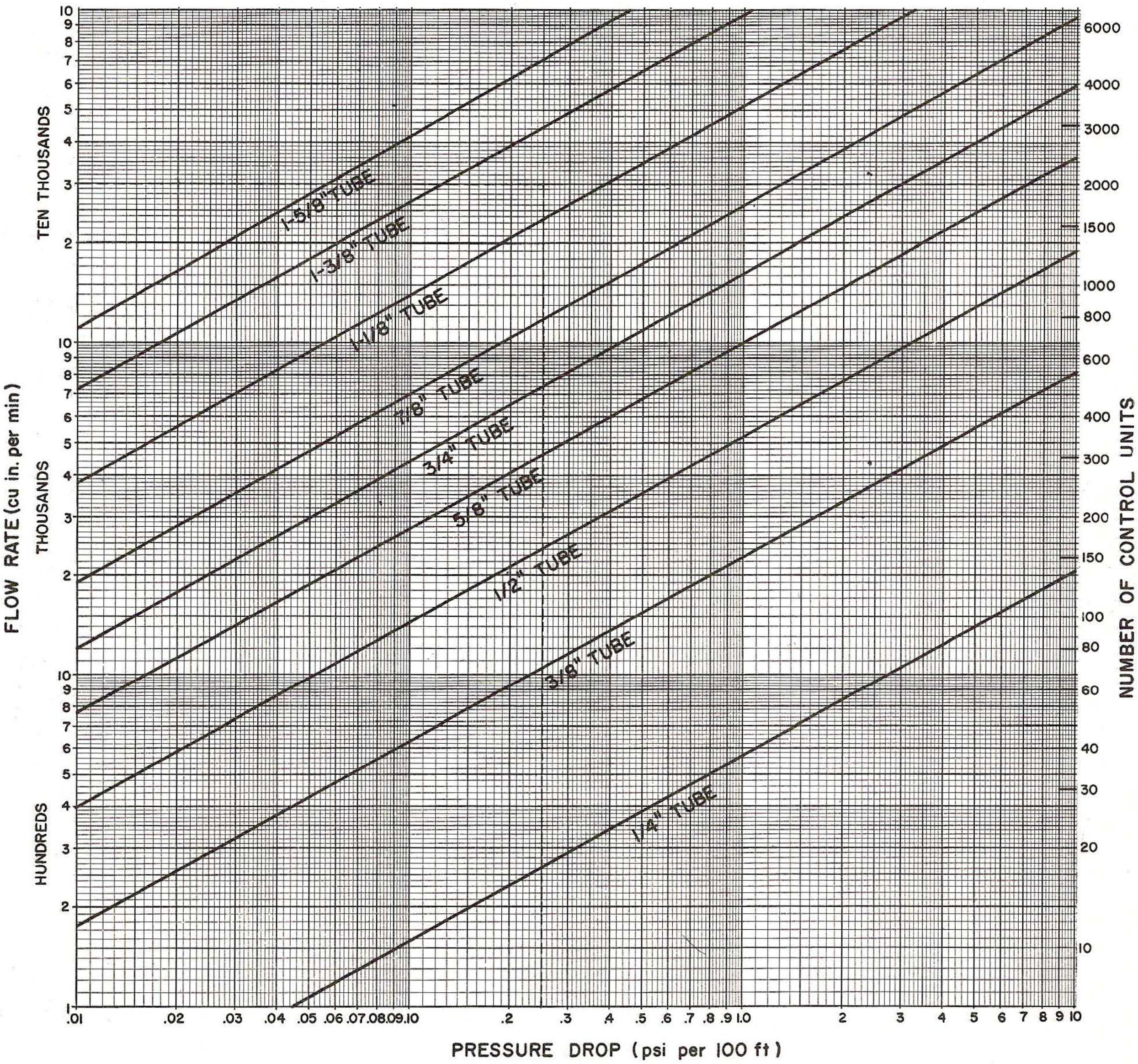
COPPER ————
PLASTIC — — —

CHART 1

SIZING AIR LINES

SUPPLY AIR PRESSURE 15 psig

DO NOT USE FOR A TOTAL PRESSURE DROP OF MORE THAN 6 psi



NOTE: ALL TUBE SIZES ARE O.D.
BASED ON 15 cim/UNIT

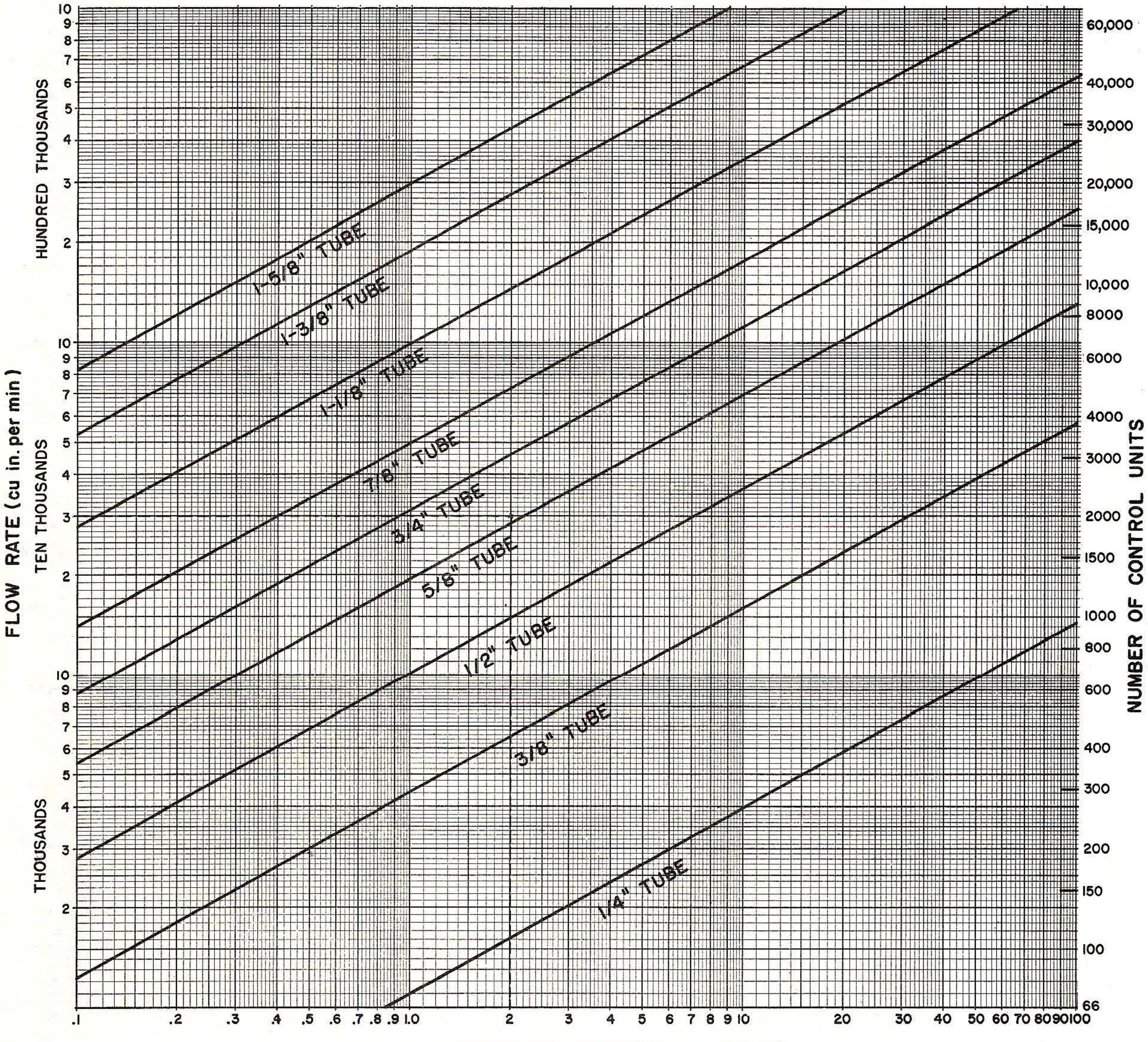
The above chart is used for determining the sizes of air mains from the quantity of air required (flow rate) and the allowable pressure drop per 100 feet of main. Flow rates are based on seamless copper tubing type L in sizes through $1\frac{1}{8}$" O.D. and Type M in sizes $1\frac{3}{8}$" and $1\frac{5}{8}$" O.D. This Chart may be used for other types of tubing without appreciable error.

CHART 2

SIZING AIR LINES

SUPPLY AIR PRESSURE 75 psig

DO NOT USE FOR A TOTAL PRESSURE DROP OF MORE THAN 20 psi



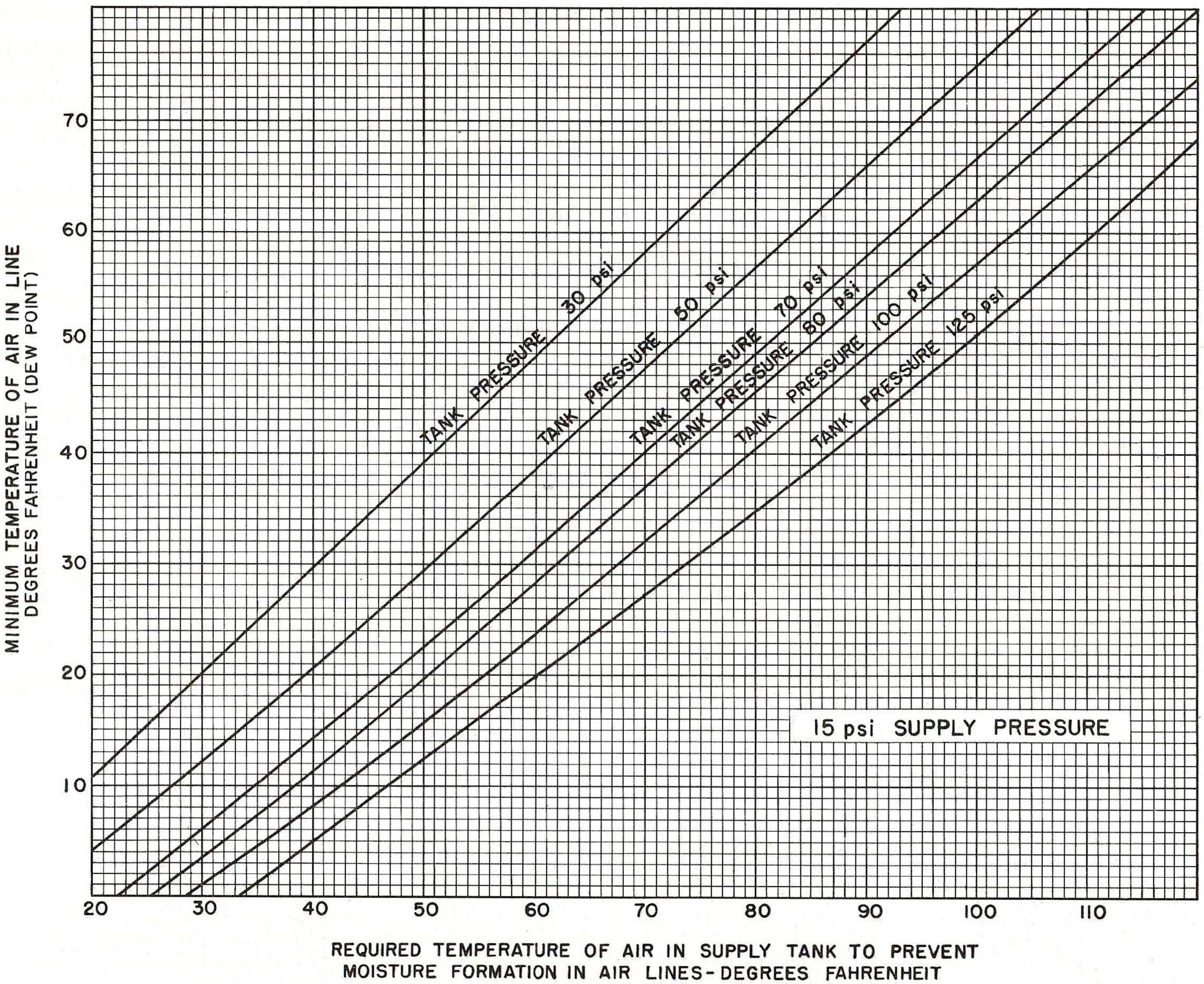
NOTE: ALL TUBE SIZES ARE O.D.
BASED ON 15 cim/UNIT

The above chart is used for determining the sizes of air mains from the quantity of air required (flow rate) and the allowable pressure drop per 100 feet of main. Flow rates are based on seamless copper tubing type L in sizes through $1\frac{1}{8}$" O.D. and Type M in sizes $1\frac{3}{8}$" and $1\frac{5}{8}$" O.D. This Chart may be used for other types of tubing without appreciable error.

CHART 3

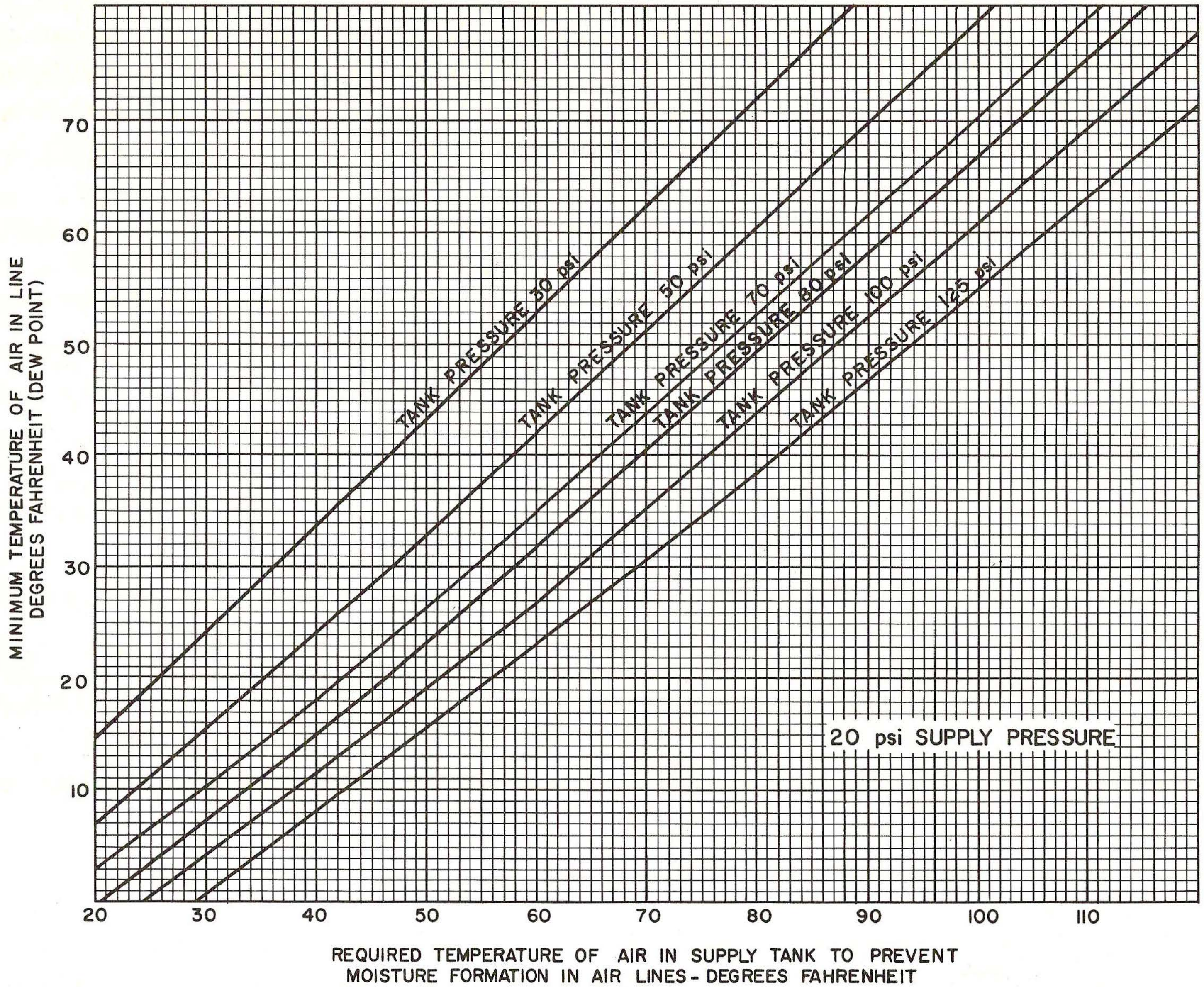
MOISTURE CONDENSATION IN AIR LINES

(15 psi Supply Pressure)



Temperature of air in supply tank = ambient temperature + 10 F°

CHART 4
MOISTURE CONDENSATION IN AIR LINES
(20 psi Supply Pressure)



Temperature of air in supply tank = ambient temperature + 10 F°