



**Oil Hydraulics and Pneumatics**  
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**Part 2: What causes Pressure Drop?, Minimizing Pressure Drop, Air Distribution System – Sizing of Pipes, Tubes, Materials and Fittings, Important Air Flow Parameters**  
**Lecture – 28**  
**Pneumatic Pressure Drop**

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**What Causes the Pressure Drop?**

- Any type of obstruction, restriction, or roughness in the system will cause resistance to air flow and cause pressure drop.
- In the distribution system, the highest pressure drops usually are found at the points-of-use, including undersized or leaking hoses, tubes, disconnects, filters, regulators and lubricators (FRLs).
- On the supply side of the system, air/lubricant separators, after coolers, moisture separators, dryers and filters can be the main items causing significant pressure drops.
- The maximum pressure drop from the supply side to the points-of-use will occur when the compressed air flow rate and temperature are highest.
- System components should be selected based upon these conditions and the manufacturer of each component should be requested to supply pressure drop information under these conditions.
- When selecting filters, remember that they will get dirty. Dirt loading characteristics are also important selection criteria.



My name is Somashekhar, course faculty for this course. So, now, we know the significance of Pressure Drop. What causes the pressure drop? Any type of obstruction, restriction or roughness in the system piping and tubing will cause the resistance to air flow and results in pressure.

In the distribution system, the highest pressure drop usually are found at the point-of-use including undersized or leaking hoses, tubes, disconnects, filters, regulators and lubricators.



On the supply side of the system, air lubricant separators, after coolers, moisture separators, dryers, filters can be the main items which causes the significant pressure drop. Both at the use and at the generation you have to take much care in reducing the pressure drop.

The maximum pressure drop from the supply side to the point-of-use will occur when the compressed air flow rate and temperature are highest. System components should be selected based upon these conditions and the manufacturer of each component should be requested to supply the pressure drop information under these conditions. When selecting filters, remember that they will get dirty. Dirty loading characteristics are also important selection criteria.

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**What Causes the Pressure Drop?**

- Large end users who purchase substantial quantities of components should work with their suppliers to ensure that products meet the desired specifications for differential pressure and other characteristics.
- The distribution piping system often is diagnosed as having excess pressure drop because a point-of-use pressure regulator cannot sustain the required downstream pressure
  - If such a regulator is set at 85 psig (584.054 kPa gauge) and the regulator and/or the upstream filter has a pressure drop of 20 psig (137.895 kPa gauge), the system upstream of the filter and regulator would have to maintain at least 105 psig (723.95 kPa gauge)
  - The 20 psig (137.895 kPa gauge), pressure drop may be blamed on the system piping rather than on the components at fault
  - The correct diagnosis requires pressure measurements at different points in the system to identify the component(s) causing the excess pressure drop
  - In this case, the filter element should be replaced or the filter regulator size needs to be increased, not the piping



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other characteristics as stated. The distribution piping system often is diagnosed as having excessive pressure drop because a point-of-use pressure regulator cannot sustain the required downstream pressure.

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### Minimizing the Pressure Drop

- It requires **systems approach in design and maintenance** of the system
- The essential requirement in **pressure drop** from the **generating point** to the **point of consumption** remains as low as possible
- For economical reasons, it is always better to keep this **total pressure drop to a maximum value of 0.1 bar or even less**
- Some of the **International Standards** prescribe this value should be **0.01 bar for a line pressure of 6 bar (g)** due to specific operational requirement
- So **proper design of the distribution system** is required which includes...
- **Air treatment components** such as **after-coolers, moisture separators, dryers, and filters**, should be selected with the lowest possible pressure drop at specified maximum operating conditions
- Similarly **specify pressure regulators, lubricators, pipe, tubes, hoses, and connections** having the best performance characteristics at the lowest pressure differential
  - These components **must be sized** based upon the **actual rate of flow** and not the average rate of flow
- **When installed all these components** → the recommended maintenance procedures should be followed and documented



It requires minimizing the pressure drop requires always the system design approach and maintenance of the system properly. The essential requirement in pressure drop from the generating point to the point of consumption remains as low as possible. For economic reasons it is always better to keep this total pressure drop to a maximum value of 0.1 bar or even less is best.

Some of the international standards prescribed this value should be 0.01 bar for a line pressure of 6 bar gauge due to specific operational requirement. So, proper design of the distribution system is required which includes the air treatment components such as after-cooler, moisture separator, dryers and filters, should be selected with lowest possible pressure drop at a specified maximum operating conditions.

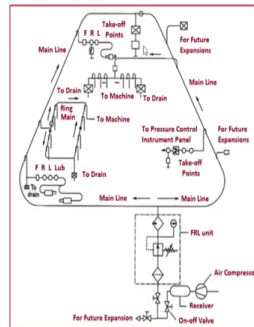
Similarly specify the pressure regulators, lubricators, pipes, tubes, hoses and connections having the best performance characteristics at the lowest pressure differential. These components must be sized based on the actual flow rate and not the average flow rate.

When installed all these components the recommended maintenance procedures should be followed and documented every time for the future references.

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### Minimizing The Pressure Drop

- Avoid/Discard the straight line and long distance piping layout so that reduce the air travel distance through the distribution system → so adopt looping system...



- Use minimum number of elbows and bends
- Place as many as water collectors in the pipeline
- Use as many as isolating valves (stop valves) in each branch pipe line



Also avoid or discard the straight line piping and tubing and long distance piping avoided, so that reduces the air travel distance through the distribution system. That is why I am telling you always adopt the looping system. You already know what is a looping system.

The compressor is here air compressor which will stores the you receiver will store the required quantity of air with required pressure, then it will supply to the various machine tools and the devices which use the air and also you will see here as many as on off valve will incorporate and, also provide the air tapping for the future expansion.

Then you will see after the receiver tank before going to the main line, it will be subjected to the secondary treatment what we call filter, regulator, lubricator units. It is a filter, regulator, lubricators then air will pass to the ring main system meaning where the air will move

through the main line to clockwise and anti-clockwise, then air will be tapped to the various stations where the pneumatic devices consumes the air.




Please take care here friends you are seen here, as much as possible you have to incorporate the filters, regulator, lubricator units along with the water traps and a filters which will ensures your efficient performance of the pneumatic components. So, use the minimum number of elbows and bends. Place as many as water collectors in the pipeline.

Use as many as isolating valves, what you will call on-off valves, stop valves each branch pipeline because this is very essential. If this branch is not working if is on-off valve is cut off this then air will through main flow it will go to the next. As and when required will open the on-off valve to the required branch otherwise no as because air losses are more in the pipe lines.

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**Air Distribution System or Pipe Layout**

- The air distribution system is made up of **fluid conductors and line fittings**, which interconnect the various components of a pneumatic system
- **Fluid conductors** are generally divided into **three classes**
  1. Pipes are rigid
  2. Tubes are rigid or semi-rigid
  3. Hoses are flexible
- More than one type of conductor may be used in the same installation
- The proper selection and installation of conductors are vital in the **efficient operation of a system**
- The choice of conductors is decided by considering the following requirements
  - ✓ Permissible pressure drop
  - ✓ Leak-proof operation
  - ✓ Resistance to corrosion



So, the air distribution system or a piping layout if we will see made up of you have seen it consists of various fluid conductors and line fittings which interconnect the various components of the pneumatic system. Fluid conductors are generally divided into 3 main classes what we will call the pipes are rigid; tubes are rigid or semi-rigid; hoses are flexible.

More than one type of fluid conductors may be used in the same installation. The proper selection and installation of conductors are vital in the efficient operation of the system. The choice of conductor is decided by considering the following important requirements: permissible pressure drop, leak-proof operations, and resistance to corrosion. These are very very essential while selecting the pipes tubes and hoses.

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- Sizes of pipe are listed by the **nominal (or approximate) ID** and **the wall thickness**.
- Pipes are available in three different weights: **1. Standard (STD) or Schedule 40** ; **2. Extra Strong (XS) or Schedule 80**; **3. Double Extra Strong (XXS)**
- The schedule numbers range from 10 to 160 and cover 10 distinct sets of wall thickness as shown in the Table below

### Sizing of Pipes



Table : Wall Thickness Schedule Designations for Pipe , mm (inch)

Nominal Size mm (inch)	Pipe OD mm (inch)	Inside Diameter [inch]										
		Sched. 10	Sched. 20	Sched. 30	Sched. 40	Sched. 60	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160	
3.175 (1/8)	10.287 (0.405)				6.833 (0.269)		5.461 (0.215)					
6.35 (1/4)	13.716 (0.540)				9.246 (0.364)		7.671 (0.303)					
9.525 (3/8)	17.145 (0.675)				12.522 (0.493)		10.744 (0.423)					
12.7 (1/2)	21.336 (0.840)				15.799 (0.622)		13.868 (0.546)			0.466		11.836 (0.466)
19.05 (3/4)	26.670 (1.050)				20.929 (0.824)		18.846 (0.742)			0.614		15.595 (0.614)
25.4 (1)	33.401 (1.315)				26.644 (1.049)		24.307 (0.957)			0.815		20.701 (0.815)
31.75 (1 1/4)	42.164 (1.660)				35.052 (1.380)		32.461 (1.278)			1.160		29.464 (1.160)
38.10 (1 1/2)	48.260 (1.900)				40.894 (1.610)		38.100 (1.500)			1.388		35.255 (1.388)
50.8 (2)	60.325 (2.375)				52.501 (2.067)		49.250 (1.939)			1.689		42.900 (1.689)

- Schedule 160 wall thickness is **slightly thinner** than double extra strong



Let us we will see sizing of pipes. Sizing of pipes are listed by the nominal or approximate ID inside diameter and the wall thickness. Pipes are available in 3 different weights, what we

will call? A standard or a scheduled 40; 2nd one is extra strong or a scheduled 80; 3rd one double extra strong.

The scheduled numbers range from 10 to 160 and cover 10 distinct sets of wall thicknesses as shown in the table. You will see here this table will show you friends, the nominal diameter it is given in the millimeter and inch in the bracket, the pipe OD and then you will see here scheduled a number 10, 20, 30, 40, 60, 80, 100, 120, 140, 160.

These are the 10 distinct sets of scheduled numbers for which I have mentioned here the thickness of the tubes in millimeter as well as an inch. Here you will see some of the thicknesses if you will see here, here, here you will see compared to the value of here and here. Then what happens scheduled 160 wall thickness is slightly thinner these are the thinner than the double extra strong pipes.

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**Sizing of Tubing**

- **Tubing** differs from **Pipe** in its size classification.
- **Sizes of tubing are listed by the actual OD** Example : 5/8-inch tubing has an OD of 5/8 inch
- Tubing is available in a **variety of wall thicknesses**
- The **diameter of tubing** is often measured and indicated in **16<sup>th</sup> of an inch**. Thus, No. 6 tubing is 6/16 inch or 3/8 inch, No. 8 tubing is 8/16 inch or 1/2 inch, and so forth





Then you will see sizing of the tubes the tube differs from pipe in its size classification. Sizing of pipes is different, sizing of tubes are different. Here in sizing of tubes are listed by the actual OD example 5 by 8 inch tubing has an OD of 5 by 8 inch.



Tubing is available in variety of wall thickness. For example, if we will see the 5 by 8 inch of OD it has a various thicknesses under this category. I will show you the table in the next slide. The diameter of tubing is often measured and indicated in 16th of an inch meaning what it is? The number 6 tubing is 6 by 16 inch or 3 by 8 inch.

Similarly number 8 tubing is 8 by 16th inch or 1 by 2 inch and so forth. Meaning the diameter of the tubing is often measured and indicated in the 16th of the inch you will see 16th of an inch, it will continue.

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### Sizing of Tubing

Tube OD (inch)	Wall Thickness (inch)	Wall Thickness (mm)	Tube ID (inch)	Tube ID (mm)
1/8	0.028	0.711	0.069	1.753
	0.032	0.813	0.061	1.549
	0.035	0.889	0.055	1.397
3/16	0.032	0.813	0.1235	3.137
	0.035	0.889	0.1175	2.985
	0.035	0.889	0.180	4.572
1/4	0.042	1.067	0.166	4.216
	0.049	1.245	0.152	3.861
	0.058	1.473	0.134	3.404
5/16	0.065	1.651	0.120	3.048
	0.035	0.889	0.2425	6.160
	0.042	1.067	0.2285	5.804
3/8	0.049	1.245	0.2145	5.448
	0.058	1.473	0.1965	4.991
	0.065	1.651	0.1825	4.638
1/2	0.035	0.889	0.305	7.747
	0.042	1.067	0.291	7.391
	0.049	1.245	0.277	7.036
3/4	0.058	1.473	0.259	6.579
	0.065	1.651	0.245	6.223
	0.035	0.889	0.430	10.922
1	0.042	1.067	0.416	10.566
	0.049	1.245	0.402	10.211
	0.058	1.473	0.384	9.754
1 1/8	0.065	1.651	0.370	9.398
	0.072	1.829	0.358	9.093
	0.083	2.108	0.334	8.484
1 1/4	0.095	2.413	0.310	7.874
	0.035	0.889	0.555	14.101
	0.042	1.067	0.541	13.745
1 1/2	0.049	1.245	0.527	13.389
	0.058	1.473	0.509	12.932
	0.065	1.651	0.495	12.576
1 3/4	0.072	1.829	0.481	12.221
	0.083	2.108	0.459	11.764
	0.095	2.413	0.435	11.307
2	0.049	1.245	0.652	16.511
	0.058	1.473	0.634	16.155
	0.065	1.651	0.620	15.800
2 1/4	0.072	1.829	0.606	15.343
	0.083	2.108	0.584	14.886
	0.095	2.413	0.560	14.429
2 1/2	0.109	2.769	0.532	13.574
	0.049	1.245	0.777	19.736
	0.058	1.473	0.759	19.279
3	0.065	1.651	0.745	18.923
	0.072	1.829	0.731	18.567
	0.083	2.108	0.709	18.009
3 1/2	0.095	2.413	0.685	17.399
	0.109	2.769	0.657	16.688
	0.049	1.245	0.907	22.911
4	0.058	1.473	0.884	22.454
	0.065	1.651	0.870	22.098
	0.072	1.829	0.856	21.742
4 1/2	0.083	2.108	0.834	21.184
	0.095	2.413	0.810	20.574
	0.109	2.769	0.782	19.863
5	0.120	3.048	0.760	19.304
	0.049	1.245	1.120	28.446
	0.058	1.473	1.106	28.092
5 1/2	0.065	1.651	1.084	27.534
	0.072	1.829	1.060	26.924
	0.083	2.108	1.032	26.213
6	0.095	2.413	1.010	25.654
	0.109	2.769	0.984	25.044
	0.120	3.048	0.960	24.434
6 1/2	0.049	1.245	1.316	33.436
	0.058	1.473	1.302	33.082
	0.065	1.651	1.276	32.472
7	0.072	1.829	1.256	31.862
	0.083	2.108	1.232	31.252
	0.095	2.413	1.208	30.642
7 1/2	0.109	2.769	1.184	30.032
	0.120	3.048	1.160	29.422
	0.049	1.245	1.552	39.424
8	0.058	1.473	1.538	39.070
	0.065	1.651	1.512	38.460
	0.072	1.829	1.488	37.850
8 1/2	0.083	2.108	1.464	37.240
	0.095	2.413	1.440	36.630
	0.109	2.769	1.416	36.020
9	0.120	3.048	1.392	35.410
	0.049	1.245	1.828	46.400
	0.058	1.473	1.814	46.046
10	0.065	1.651	1.788	45.436
	0.072	1.829	1.764	44.826
	0.083	2.108	1.740	44.216
10 1/2	0.095	2.413	1.716	43.606
	0.109	2.769	1.692	42.996
	0.120	3.048	1.668	42.386
11	0.134	3.404	1.644	41.776
	0.049	1.245	2.160	54.912
	0.058	1.473	2.146	54.558
12	0.065	1.651	2.120	53.948
	0.072	1.829	2.096	53.338
	0.083	2.108	2.072	52.728
12 1/2	0.095	2.413	2.048	52.118
	0.109	2.769	2.024	51.508
	0.120	3.048	2.000	50.898
13	0.134	3.404	1.976	50.288


Here I am showing you the different types of tube OD wall thicknesses. Tube OD it is 1 by 8th inch, 3 by 16th, 1 by 4 different tube OD and corresponding wall thicknesses in inch millimeter. Similarly, tube ID and tube ID inch and millimeter; this these are all you will get all this information in the pneumatic manuals based on your requirement you will choose the required OD and corresponding wall thicknesses.



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### Pipe Materials

- Due to low pressure application of pneumatics, selection of tube material for the compressed air system **may not be of a very important criterion**
- But the **maintenance mechanic** should have an idea of the **pressure range for all these pipe materials**
- **Different types of pipe material in use today are** Galvanized Iron (GI) Pipes, Cast Iron (CI) Pipes, Copper Tubes, Aluminum Tubes, Brass Tube, Rubber Hoses, Plastic Hoses, Nylon Hoses, High Strength Steel Pipes, Reinforced Rubber Hoses or Plastic Hoses etc.
- The following table gives the **tolerable pressure range** for some common types of pipe materials

Sl. No.	Pipe Material	Maximum Pressure (bar)
1	Copper	250
2	Aluminum	125
3	Brass	200
4	Stainless steel	2500 to 4500
5	Polythene at 80 °C	12 to 15
6	Nylon at 25 °C	7 to 10
7	Vinyl at 25 °C	8 to 10
8	Rubber at 80 °C	3 to 7



Then, materials for the pipe as well as the tubes. Due to low pressure application of pneumatics as I have told you 6 to 10 bar is a normal pneumatics the people will never go beyond 20 bar. So, due to low pressure application of pneumatics selection of tube material for compressed air system may not be of very important criteria.

But, the maintenance mechanics should have an idea of the pressure range for all these pipe materials as well as tube materials. Different types of pipe materials in use today are























galvanized iron pipes, GI pipes it is called; cast iron or a CI pipes; copper tubes; aluminum tubes; brass tube; rubber hoses; plastic hoses; nylon hoses; high strength steel pipes; then reinforced rubber hoses or a plastic hoses and many more.


The following table gives the tolerable pressure range for some common types of pipe materials. Here I am writing here the different types of pipe materials and here I am writing the maximum pressure range. Again, all these things you will get it in the catalog meaning copper pipe you can withstand up to 250 bar; aluminum 125 bar; brass 200 bar; stainless steel 2500 to 4500 bar.


Even though we are not going, you must have the knowledge of what is the pressure rating for the different materials. For example, nylon you will see 7 to 10 bar, vinyl you will see 8 to 10 bar, rubber at 80 degree centigrade 3 to 7 bar. Meaning what is very important each pipe and tubing materials having the maximum pressure range to withstand.

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**Pipe Fittings**

 O-seal Mail Connector Pipe Thread	 O-seal Straight Thread Connector	 Reducer	 Bulk Head Union	
 Female Elbow	 Male Elbow	 45° Male Elbow	 Male Branch Tee	
 Union Tee	 Union Cross	 Flexible Metal Hose Connector	 Plug	
 Male Connector Straight Thread Boss	 Female Connector	 Swage Lock to an Adapter	 Cap	
 Bulk Head Reducer	 Port Connector	 Reducing Port Connector		





Then we will see the pipe fittings: during the air distribution system we are using the various pipes hoses correct, but so many connectors we are using, what are these? You will see there are different connectors we are using see here the O-seal mail connector for pipe thread, O-seal straight thread connector how it looks, reducers, bulkhead union, you see female elbows, male elbows, 45 degree male elbow, then male branch tees. We will see her also there are various types of pipe fittings are used in the piping's layout.

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**Important Air Flow Parameters**

1. Initial pressure ( $p_1$ )
2. Pressure at the end-of use ( $p_2$ )
3. Differential pressure ( $\Delta p = p_1 - p_2$ )
4. Size of the orifice ( $d$ )
5. Shape of the orifice
6. Smoothness of wall of the air path, depends on wall coefficient (C) of the pipe/tube




Then important airflow parameters, what are the parameter affecting to the airflow in the piping's and tubing's? Initial pressure  $p_1$ , pressure at the end of use  $p_2$ , differential pressure  $p_1$  minus  $p_2$ , size of the orifice very important  $d$ , then shape of the orifice. There are different types of orifices are available concentric orifice, square edged orifice, conical edged orifice, quadrant edged orifice, eccentric orifice and many more; meaning shape of the orifice will also affects the airflow.

Then smoothness of the wall of the air path, depending on the wall coefficient of the pipe and tube. The tube inside surface roughness will affects to the airflow if it is a rough there is a resistance to flow then pressure drop will increases. That is why for each type of pipe or a tube inside wall roughness they will specify what is C for the various types of entry and exit of the airflow.

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**Main Factors of Interest in Distribution System**

- A well-organized air distribution system is so designed that it has minimum number of elbows and bends connecting its pipes and components to ensure that the pressure energy is not wasted
- So, the distribution of compressed air should be planned and executed carefully by taking into account the following important factors while calculating the pressure drops...
  1. Compressed air pressure ( $p$ ) in the pipelines
  2. Total flow rate per unit time ( $Q$ ) through the pipelines
  3. Permissible pressure drop ( $\Delta p$ ) in the pipelines
  4. Length ( $l$ ), diameter ( $d$ ) and thickness ( $t$ ) of the pipe/tube and its material properties
  5. Flow resistances of air flow (wall coefficient,  $C$ )



Now, quickly we will see the main factors of interest in distribution system. A well-organized air distribution system is so designed that it has a minimum number of elbows and bends, correct friends? Connecting it is pipes and a components to ensure that the pressure energy is not wasted.

So, the distribution of compressed air should be planned and executed carefully by taking into account the following important factors while calculating the pressure drop. What are those? Compressed air pressure in the pipelines, total flow rate per unit time through the pipelines, permissible pressure drop in the pipelines, length, diameter, thickness of the pipe and a tube and it is material properties.

Then as I have told you the flow resistance of air in the tube or pipe matters, meaning wall coefficient is playing a major role.