Technical Guide

"Compressed Air System and Its Components"

Small and Medium Enterprises Development Authority

Ministry of Industries & Production

Government of Pakistan

www.smeda.org.pk

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2. Introduction to SMEDA

The Small and Medium Enterprises Development Authority (SMEDA) was established in October 1998 with an objective to provide fresh impetus to the economy through development of Small and Medium Enterprises (SMEs).

With a mission "to assist in Employment Generation and Value Addition to the national income, through development of SME sectors, by helping increase the number, scale and competitiveness of SMEs", SMEDA has carried out 'sectoral research' to identify Policy, Access to Finance, Business Development Services, strategic initiatives and institutional collaboration & networking initiatives.

Preparation and dissemination of prefeasibility studies in key areas of investment has been a successful hallmark of SME facilitation by SMEDA.

Concurrent to the prefeasibility studies, a broad spectrum of Business Development Services is also offered to the SMEs by SMEDA. These services include identification of experts and consultants and delivery of need-based capacity building programs of different types in addition to business guidance through help desk services.

2.1 Industry Support Program

In order to enhance competitiveness of SMEs and achieve operational excellence, SMEDA established an Industry Support Cell (ISC) for provision of foreign technical support and knowledge transfer in collaboration with International Development Organizations. SMEDA's Industry Support Program (ISP) initially launched with Japan International Cooperation Agency (JICA) and actively engaged in reducing energy inefficiencies and improving production and quality of products with the support of Japanese Experts. Later on, similar activities with other international partner organizations like German Corporation for International Cooperation (GIZ), Training and Development Centres of the Bavarian Employers' Association (bfz), Germany, and United Nations Industrial Development Organization (UNIDO) were also successfully implemented.

3. Compressed Air System

Compressed air is a form of stored energy that is commonly used to operate machinery, equipment or processes. Compressed air is generated through compressors, powered by electricity, a typical air compressor takes about 7 volumes of air at atmospheric conditions, and squeezes it into 1 volume at elevated pressure (about 7 bar). The resulting high-pressure air is distributed to equipment or tools where it releases useful energy to the operating tool or equipment's and from there it expands back to atmospheric pressure.

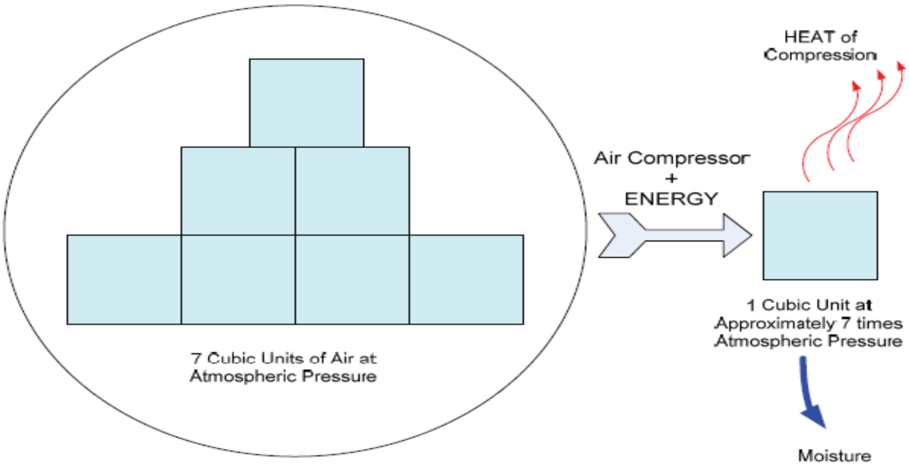

Figure 1: Production Cycle of Compressed Air

In the process of compression. And the subsequent cooling of air to surrounding temperature, heat and moisture, are released as result of process, illustrated in figure1. Depending on application, excessive moisture in compressed air needs to be managed as it causes problems with piping (corrosion) and end use equipment.

4. Compressor Air System Components

Compressed air system consists of a number of major subsystem and components. And it is subdivided into the **Supply** and **Demand** side.

4.1 Supply Side

4.1.1 Design and operational Standards

The **Supply** side includes **compressors**, **air treatments** and **primary storage**. A properly managed supply side will result in clean, dry, stable air being delivered at the appropriate pressure in dependable, cost effective manner. Major compressed air supply includes subsystem typically includes the air intake, air compressor (fixed speed or/ variable speed). After cooler, motor, controls, treatment equipment and accessories.

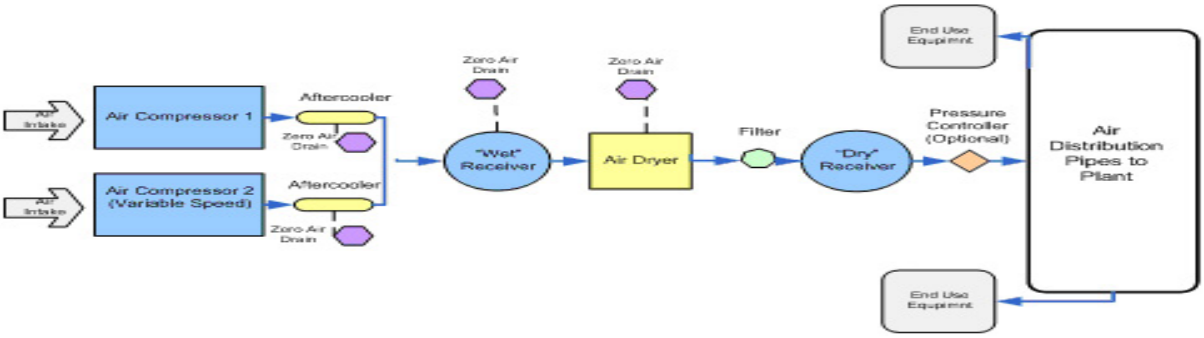

Figure 2: Air Compressor System Components

Control serve to adjust the amount of compressed air being produced to maintain constant system pressure and manage the interaction between system components. Air filter and air dryers remove moisture, oil and contaminants from the compressed air. Compressed air storage (**wet** or **dry receiver**) can also be used to improve system efficiency and stability. Accumulated water is manually or automatically discharged through drain. Optional pressure controllers (**pressure regulator)** are used to maintain a constant required pressure at an end use machine.

4.1.2 Compressor Room:

Many facilities have issues with compressor room temperature regulation. This is due in large part(equipment's) to inappropriate planning. Too often the compressor room is the last part of the facility considered when building a new plant or retrofitting an old one. As a result, the compressed air system is installed wherever space is left usually alongside boilers or other equipment. Most compressed air systems have standard temperature ratings between 40 F and 115 F. However, refrigerated and heated desiccant dryers have correction factors when inlet temperatures rise above or fall below 100 F, careful consideration should be considered for ambient conditions for both summer and winter.

Ventilation has a huge impact on the ambient temperature in the compressor room and is often the missing link to temperature regulation issues.

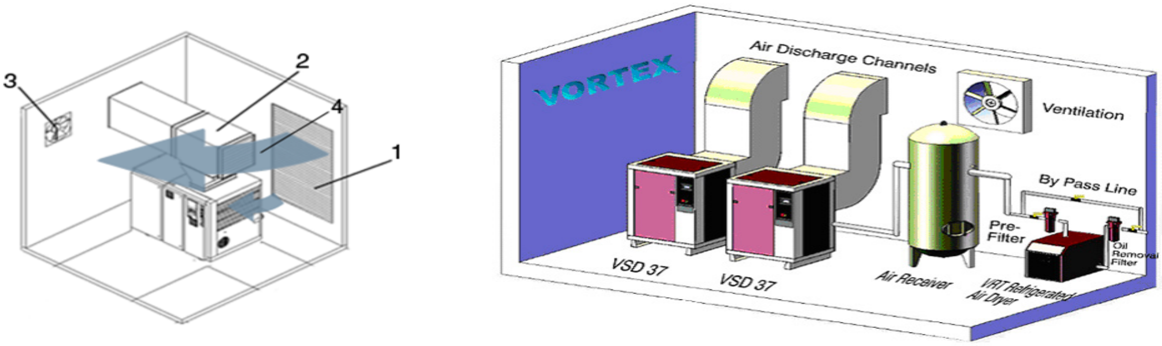

Figure 3: Compressor Room Design

4.1.3 After-Cooler:

After-coolers are heat exchangers for cooling the discharge from the air compressor. They use either air or water and are an effective means of removing moisture from compressed air. After-coolers reduce the amount of water vapor in a compressed air system by condensing the water vapor into liquid form.

After-coolers combined with a separator are an excellent way to reduce moisture in a compressed air system. In a distribution or process manufacturing system, liquid water causes significant damage to equipment. An after-cooler is necessary to ensure the proper functionality of pneumatic or air handling devices that are a part of process manufacturing systems. After-coolers can use either air-cooled or water-cooled mechanisms.

Figure 4 :After-Cooler Assembly

4.1.4 Primary Storage/Receiver Tank:

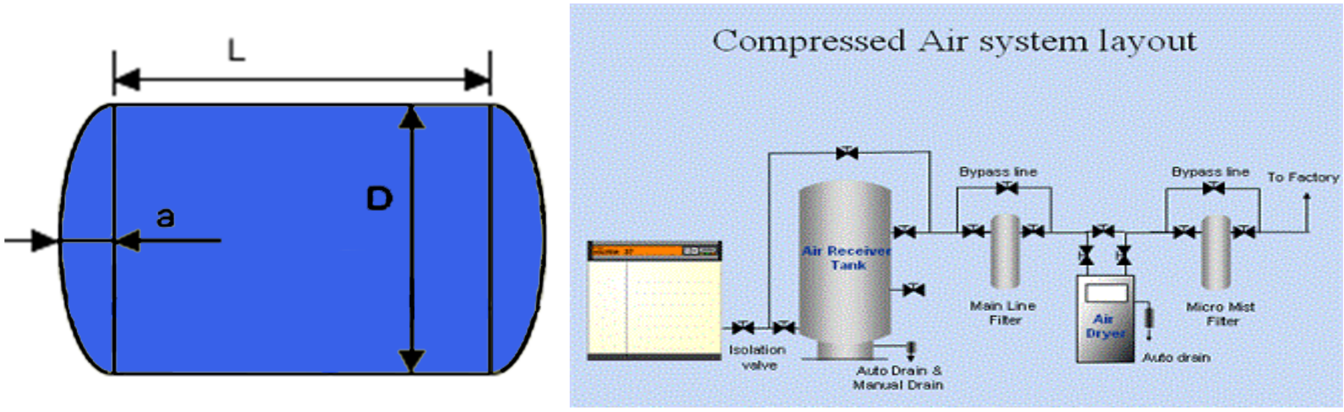

Figure 5:Primary Storage Tank

An air receiver tank is an integral and important part of any compressed air system. Typically, a receiver tank is sized at 6-10 times the flow rate of the system. So, if a compressor has a rating of 25 scfm at 100 psig, the receiver tank should be 150 cubic feet, minimum. In a compressed air system, a receiver tank provides the following benefits:

- The receiver tank acts as a reservoir of compressed air for peak demands.
- The receiver tank will help remove water from the system by allowing the air a chance to cool.
- The receiver tank minimizes pulsation in the system caused by a reciprocating compressor or a cyclic process downstream.

An air receiver tank compensates for peak demand and helps balance the supply of the compressor with the demand of the system.

Receiver tanks are required by law to have a pressure relief valve and a pressure gauge. The relief valve should be set to 10% higher than the working pressure of the system. It is also important to install either a manual or automatic drain on the receiver tank to remove water from the system.

A coalescing filter and air dryer are best placed downstream of the receiver tank. Automatic air release safety valve, pressure gauge and auto drain must be installed to meet standard requirements.

4.1.5 Pre-filter:

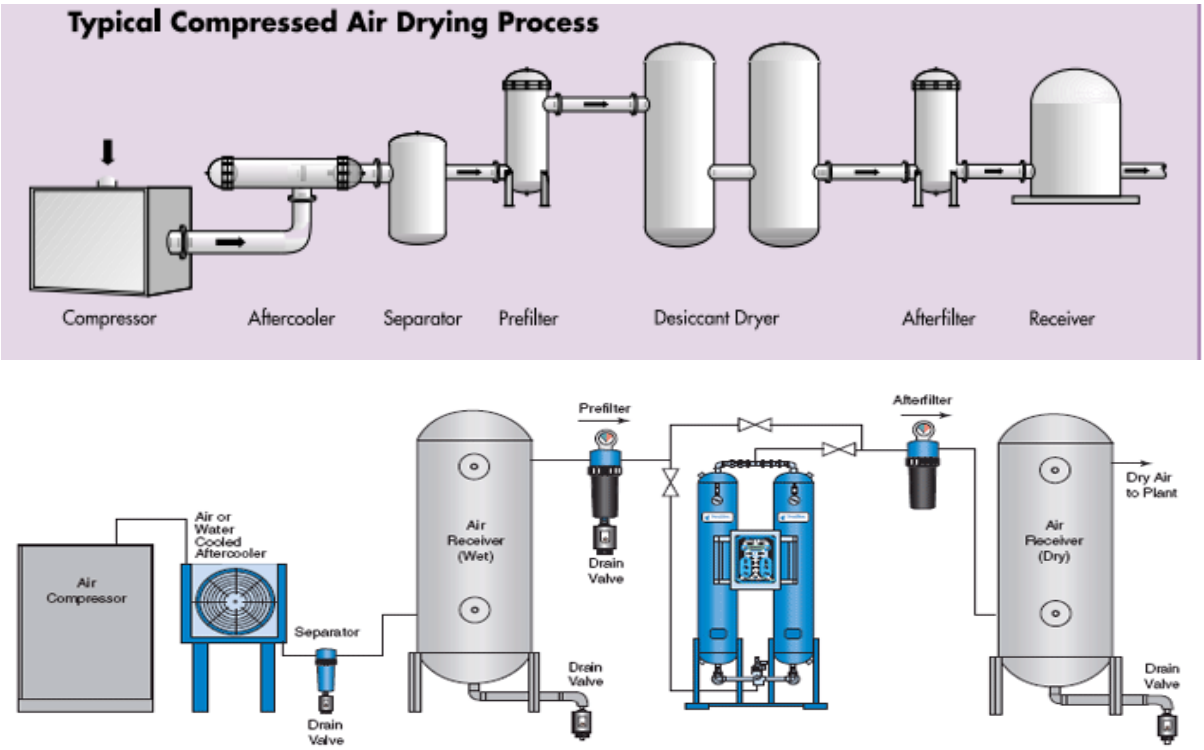

Figure 6: Arrangement of Filters in Compressed air system

While the dryer is an integral part of achieving clean, dry air, additional treatment is often necessary to ensure proper system performance and good performance of dryers. Compressed air filters help protect equipment from dust, dirt, oil and water. Particulate matter normally refers to solid particles in the air and it has been estimated that there are as many as 4 million particles in one cubic foot of atmospheric air. When compressed to 103 psig (7.1 bar) the concentration becomes over 30 million. Over 80% of these are below 2 microns.

One micron = One millionth of a meter or = 0.04 thousandths of an inch

The inlet filter of a typical air compressor has a rating of about 10 microns and is designed for the protection of the air compressor and not any downstream equipment. In addition, wear particles from compressors and deposits from degradation of oils exposed to the heat of compression can add to downstream contamination. The main mechanisms of mechanical filtration are **direct interception, inertial impaction, and diffusion.**

Direct interception occurs when a particle collides with a fiber of the filter medium without deviating out of the streamline flow. Usually this occurs on the surface of the filter element and affects mainly the larger sized particles (usually over 1 micron).

Inertial impaction occurs when a particle, traveling in the air stream through the maze of fibres in the filter element, is unable to stay in the streamline flow, collides with a fiber, and adheres to it. Usually this occurs with particles in the range from 0.3 to 1.0 microns.

Diffusion (or Brownian Motion) occurs with the smallest particles, below 0.3 microns. These tend to wander through the filter element within the air stream, with increased probability of colliding with a filter fibre and adhering to it.

4.1.6 Particulate Filters:

Particulates enter the system from the air intake, originate in the compressor due to mechanical action, or are released from some air-drying systems. These particles erode piping and valves or cause product contamination. However, the most harmful effect is clogged orifices or passages of tools and so forth at end-use points. These particulates include ***metal fines, carbon and Teflon particles, pollen, dust, rust, and scale***. Organisms enter through the inlet and reproduce in a moist warm environment. Particulate filter designs are such that some overlap occurs with the different mechanisms and the desired degree of contaminant removal. A higher degree of contaminant removal than is necessary will result in a higher pressure drop across the filter, requiring a higher pressure from the air compressor and additional energy costs.

A particulate filter is recommended downstream of the air dryer, ahead of any operational equipment or process.

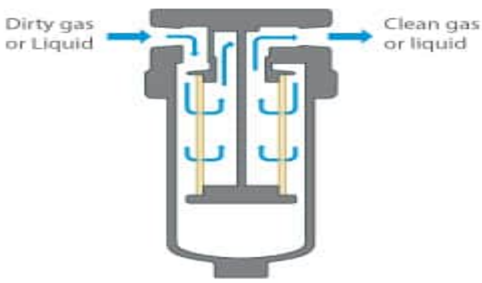

Figure 7: Particulate Filter

4.1.7 Coalescing Filters:

Small droplets of moisture or oil adhere to the filter medium and coalesce into larger liquid droplets. Flow through the filter element is from the inside to the outside where the larger diameter allows a lower exit velocity. An anti-re-entrainment barrier normally is provided to prevent droplets from being re-introduced to the air stream. The cellular structure allows the coalesced liquid to run down by gravity to the bottom of the filter bowl from which it can be drained, usually by means of an automatic drain. The liquid may contain both oil and water.

A coalescing filter is recommended ahead of any dryer with drying medium may be damaged by oil. The term oil includes petroleum based and synthetic hydrocarbons plus other synthetic oils such as di-esters which can affect materials such as acrylics in downstream equipment or processes.

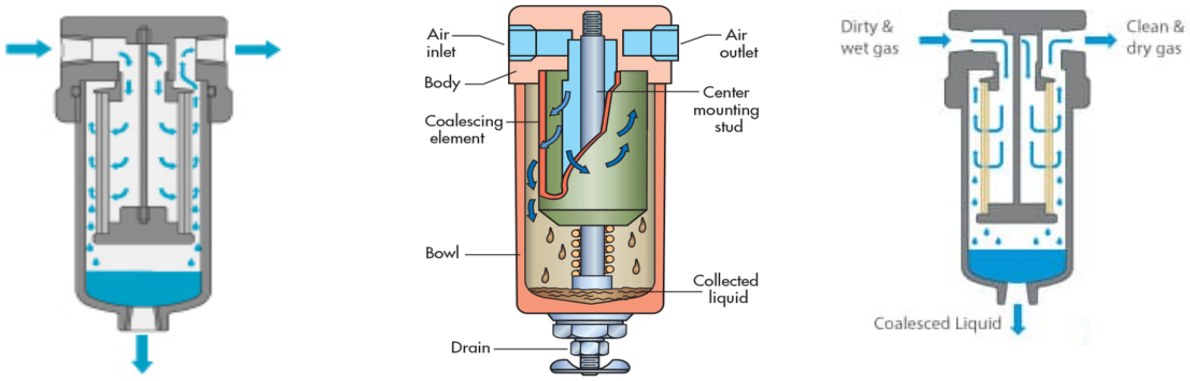

Figure 8: Coalescing Filter

4.1.8 Adsorption Type Filters:

Particulate and coalescing type filters remove extremely small solid or liquid particles down to 0.01 microns but not oil vapours or odours. Adsorption is the attraction and adhesion of gaseous and liquid molecules to the surface of a solid. Normally the filter elements contain activated carbon granules which have an extremely high surface area and dwell time. The activated carbon medium is for the adsorption of vapours only. An adsorption filter must be protected by an upstream coalescing type filter to prevent gross contamination by liquid oil. With the combination of all three types of filters downstream of a dryer, it is possible to obtain an air quality better than the atmospheric air entering the air compressor.

4.1.9 Compressed Air Quality

Compressed air leaving an air compressor is not normally of a quality suitable for the intended use. This is due to several factors:

- **Atmospheric air**, especially in an industrial environment, contains particulate matter, moisture and hydrocarbons.
- **The inlet filter** on an air compressor is a particulate filter, designed to protect the compressor rather than downstream equipment.
- **The air compressor** itself will contribute contaminants in the form of wear particles and compressor oil carry-over. The discharge temperature from the compressor may be too high for distribution and use.

Cooling after compression results in condensation of moisture vapor and saturated air leaving the after-cooler. Moisture has a harmful effect on pneumatic tools, air operated equipment and processes.

Compressed air quality classes are defined in the International Organization for Standardization (ISO) standard 8573-1.

4.1.10 Dryer and Filter Arrangements

As per Air Quality Classes of ISO 8573-1, there are three classes. The first class concerns particulate content, the second moisture content, and the third hydrocarbons. A general-purpose coalescing filter capable of removing particles down to 1 micron, and liquids down to 0.5 ppm (rated at 70°F), placed after an air after-cooler and moisture separator, will meet the requirement of Classes 1.4.1.(Class 1 particulate, Class 4 for moisture and Class 1 for hydrocarbons) and the arrangement is shown in below figure.

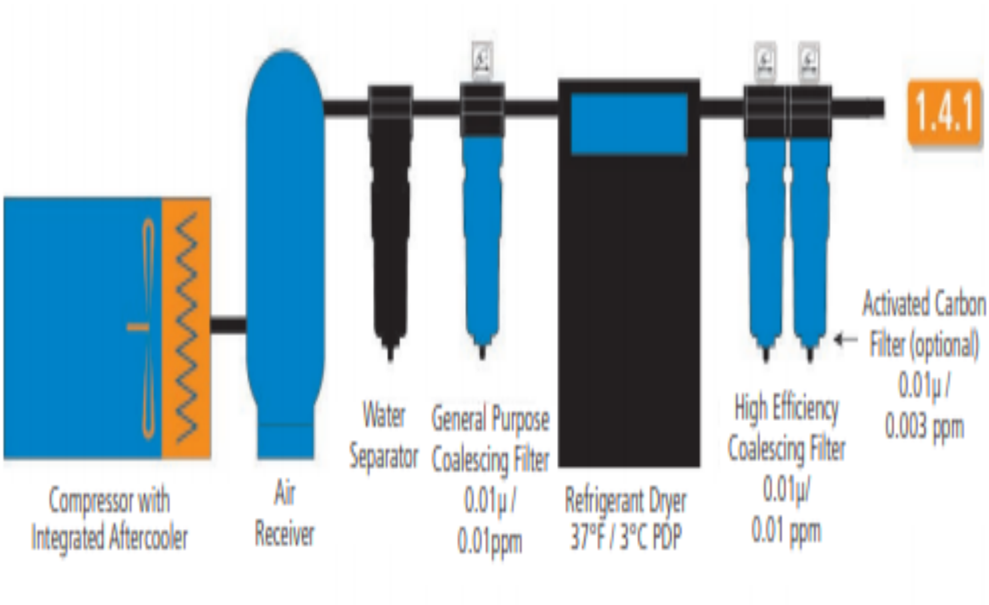

Figure 9: Arrangement as Per Air Quality

4.1.11 Automatic Condensate Drains:

Condensate accumulates at various points in the compressed air system, including bulk liquid separators, air receivers, refrigerated and deliquescent dryers, coalescing filters, and drip legs. This liquid must be regularly removed from the system to prevent harmful carryover. Automating this task improves system reliability. When selecting an automatic condensate drain, factors to consider are resistance to clogging or fouling, initial cost, utility requirements, and air loss (a measure of energy efficiency).

Figure 10: Auto Drain

4.2 Demand Side:

4.2.1 Design and operational Standards

The **Demand** side includes **distribution piping**, **secondary storage** and **end use equipment**. A properly managed demand side minimizes pressure deferential, reduces wasted air from leakage and drainage and utilizes compressed air for appropriate application. Distribution piping systems transport compressed air from the air compressor to the end use point where it is required. Compressed air storage receiver on the demand side can also use to improve system pressure stability.

As a rule of thumb, for every horsepower (HP) in the nameplate capacity, the air compressor will produce approximately 4 standard cubic feet per minute (scfm).

4.2.2 Compressed Air Piping Networks

Designing the correct pipe size for compressed air distribution system is crucial as if pipe is too small then it can create pressure losses and reduced operating efficiency. Replacing the whole piping is an expensive task therefore it is advised to design it properly during planning phase.

Some safety factor must be also incorporated into the system design to accommodate additional pressure drop for some period of extremely high use if appropriate for the facility.

4.2.3 Design Sequence

- Locate and identify each process, work station, or piece of equipment using compressed air. This is known as the total connected load. These elements should be located on a plan, and a complete list should be made to simplify record keeping.
- Determine volume of air used at each location.

- Determine pressure range required at each location.
- Determine conditioning requirements for each item, such as allowable moisture content, particulate size, and oil content.
- Establish how much time the individual tool or process will be in actual use for a specific period of time. This is referred to as the duty cycle.
- Establish the maximum number of locations that may be used simultaneously on each branch, main header, and for the project as a whole. This is known as the use factor. This information will help determine the simultaneous-use factor by eliminating some locations during periods of use at other locations.
- Establish the extent of allowable leakage.
- Establish any allowance for future expansion.
- Make a preliminary piping layout, and assign preliminary pressure drop.
- Select the air compressor type, conditioning equipment, equipment and air inlet locations making sure that consistent scfm (scmm) or acfm (acmm) is used for both the system and compressor capacity rating.
- Produce a final piping layout, and size the piping network.

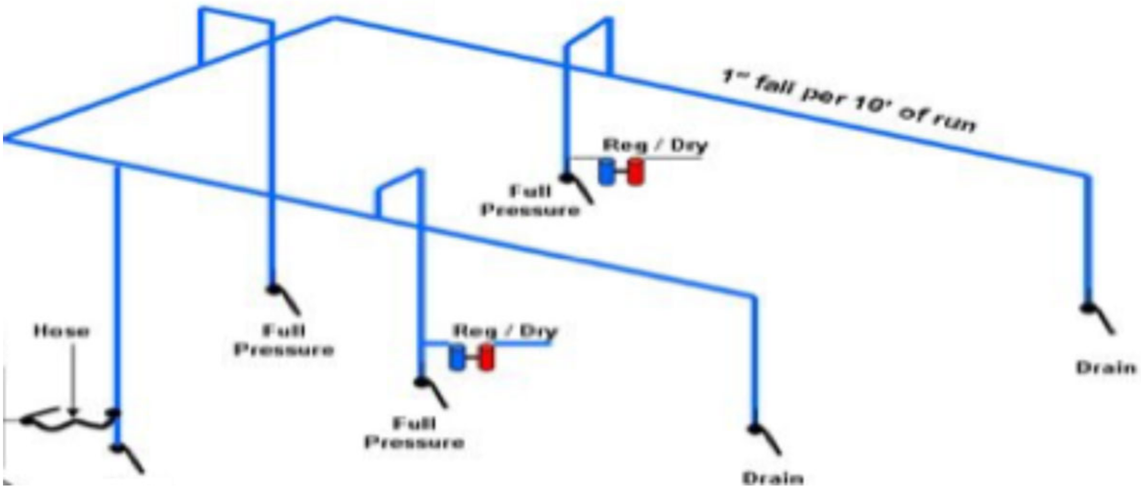

Figure 11:Standard Air Piping Network

4.2.4 Pressure and Flow Rate Requirement

All tools use air either through an orifice or to drive a piston to do work. The data relative to pressure and flow rate parameters for individual equipment and tools are usually obtained from the manufacturer, end-user, facility planner, or owner. It is quite common for this information to be incomplete, with additional investigation required to find the specific values needed. Very often, it is useful to assign preliminary pressure and flow rate requirements of the system, in order to arrange equipment space and give preliminary mechanical data to other disciplines. The picture below gives idea about general air requirements for various tools.

Tools or equipment	Size or type[a]	Air pressure, psi	Air consum scfm[b]
Hoists	1 ton	70–100	1
Blow guns		70–90	3
Bus or truck lifts	14,000-lb cap	70–90	10
Car lifts	8,000-lb cap	70–90	6
Car rockers		70–90	6
Drills, rotary	¼-in cap	70–90	20–90
Engine, cleaning		70–90	5
Grease guns		70–90	4
Grinders	8″-in wheel	70–90	50
Grinders	6″-in wheel	70–90	20
Paint sprayers	Production gun	40–70	20
Spring oilers		40–70	4
Paint sprayers	Small hand	70–90	2–7
Riveters	Small to large	70–90	10–35
Drills, piston	½-in cap, 3-in cap	70–90	50–110
Spark plug cleaners	Reach 36–45	70–90	5
Carving tools		70–90	10–15
Rotary sanders		70–90	50

Figure 12: Pneumatic Tool Consumption