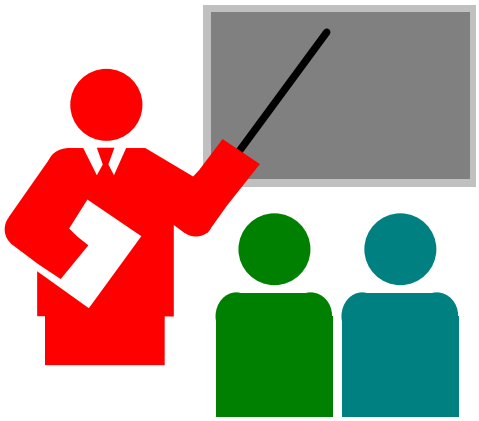
AIR GAGING 101



I OVERVIEW

Air gaging is a simple measurement tool for indicating whether a part is "good" or "bad" and with proper setting can tell the deviation from a nominal dimension. Because of the characteristics of Air Gaging, it is usually restricted to tight tolerances and short measuring ranges. This type of tooling is most commonly used for high volume production where parts may be a little dirty and the cleansing effect of the air gage speeds the measurement process. The following is a quick and basic approach to understanding the fundamentals of air gaging.

II AIR GAGING BASIC PRINCIPALS

Looking at a plain, simple air circuit and an open nozzle (Fig.1), we have the following requirements:

1. A regulated air supply.
2. A restriction so that the regulated supply does not flow through the nozzle at all times.
3. A nozzle.

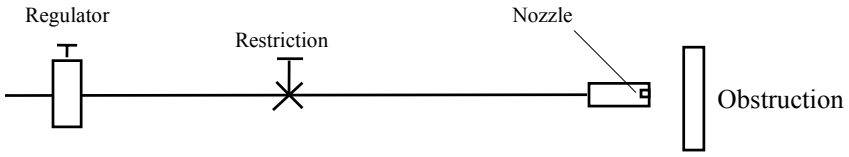


Figure 1 Simple Air Circuit Schematic

The air from the regulated supply will flow through the restriction and then through the nozzle. When the nozzle is free and open to atmosphere, there will be a maximum flow through the nozzle and there will be a minimum pressure in the system down stream of the restriction. The pressure in this down stream area is known as the open nozzle pressure. If we now place a plate

in front of the nozzle, and slowly bring it towards the nozzle, we restrict the flow and make it gradually diminish until we shut the nozzle off, at which time it will be zero. Once we have closed the nozzle off, the pressure down stream of the restriction will gradually build up until it is the same as the regulated supply, and thus at its maximum.

As we can see, both flow and pressure are inversely correlated in that both behave in opposite directions as clearance distance is adjusted. If we could measure these two conditions, we would have a means of detecting how far away the plate is from the nozzle. The two conditions that we could be measuring are:

1. The change of flow
2. The change of pressure

This is, of course, in itself not an air gage, and before we can build an air gage, we must investigate the relationship between the distance from the nozzle to the surface being measured and the flow or pressure change resulting. It so happens that under certain circumstances, we are quite lucky and there is a direct relationship between the clearance and pressure or flow. Plotting the curve of distance versus pressure from a nozzle we have:

Figure 2 Air Flow and Pressure Curves Relative to Clearance

We can see from the diagrams in Figure 2 that, apart from the extremes of pressure and flow, the curves are straight lines. This, then, is the basis on which all of our air gages work.

Let us look for a little while at the most common form of tooling in use today..... the two-jet air plug (Fig.3).

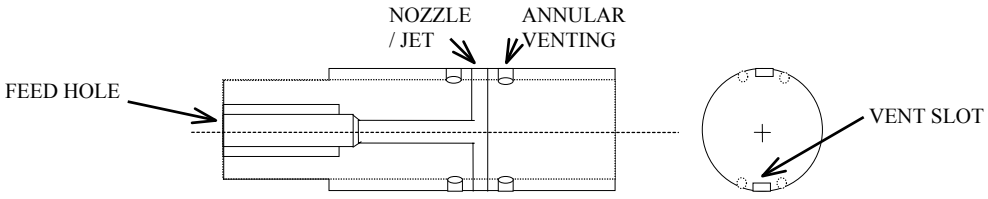


Figure 3 Basic 2-Jet Air Plug

This is a very useful component and the reason it works well is that the operator requires absolutely no skill in measuring the hole. He merely has to place the plug in the hole, and take a reading from the air gage. Obviously, this must require that the plug can be moved sideways in the hole to the limits of its clearance and yet give a constant reading. This is achieved very nicely by the two-nozzle air plug, or for that matter, by any multiple-nozzles air plug. As you move the product part toward one nozzle, you decrease the flow in that nozzle and increase it on

the other. Thus, the total flow remains constant and the indicating device (float or meter hand) does not move.

One of the items that an air gage requires is a very good filter/regulator as contamination will affect the relationships of the air measuring process and produce unreliable readings.

III AIR GAGE SYSTEMS

Introduction - a little history

In 1943, Moore Products Company, designed a system that is the basis on which the modern day backpressure air gages operate. One of its important features was the use of the nullmatic pressure regulator, which was a new idea in the regulation of gases at that time.
The simple backpressure system is shown Figure 4.

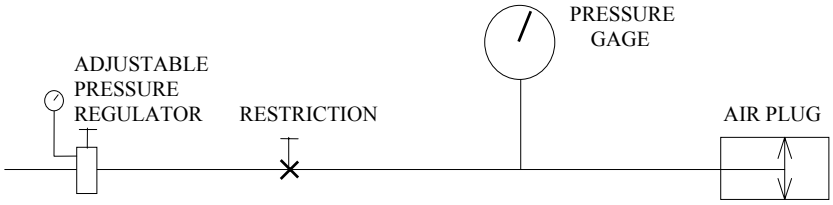


Figure 4 Simple Back Pressure Diagram

About the same time, the Sheffield Corporation decided that they would prefer to measure the flow variation in the system rather than the backpressure. There are many points to be said for both the systems, which we will discuss. The simple flow system is shown in Figure 5. These systems are not manufactured any longer, but thousands are in us and it is useful to know their operating characteristics.

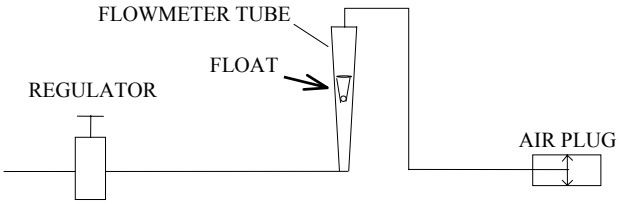


Figure 5 Simple Flow System

In the early 50's, Federal Products introduced the Balanced Air Gage, Figure 6. While it still used the same design characteristic learned from the pressure distance curve, it took it to a slight higher level. By building the air gage and tooling to higher manufacturing standards, that used the exact characteristics of the curve, Federal was able to consistently place the air systems in the mid point of the pressure curve and it in effect created the single master air gage.

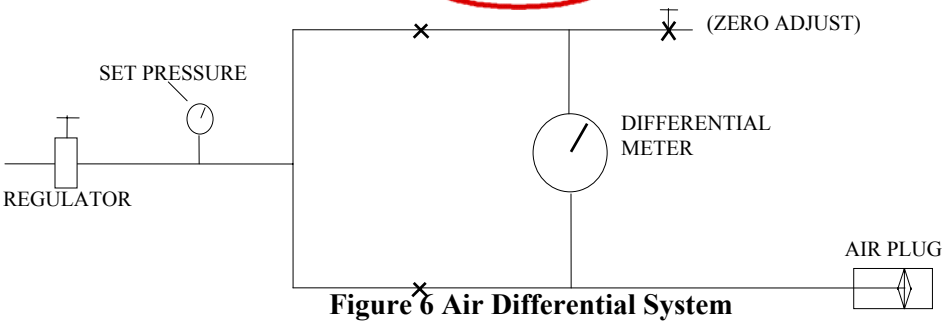


Figure 6 Air Differential System

Air Gage Characteristics

A) <u>Back-Pressure Column Type</u>
<u>Backpressure Dial Type</u> (Bleed Circuit)

Note: These two circuits are described together, as the use of a column or a dial merely represents two separate ways of indicating the result of the air gaging.

The diagram of the backpressure type system is shown in Figure 7. This system has a very good range of magnifications, which are available by use of interchangeable columns or dials. The magnification and the zero position of each tube are set by means of the two control knobs and the use of two master rings. This type of system is commonly used for "go" / "no go" applications. Though now with better regulators and digital outputs, it can provide data collection capabilities.

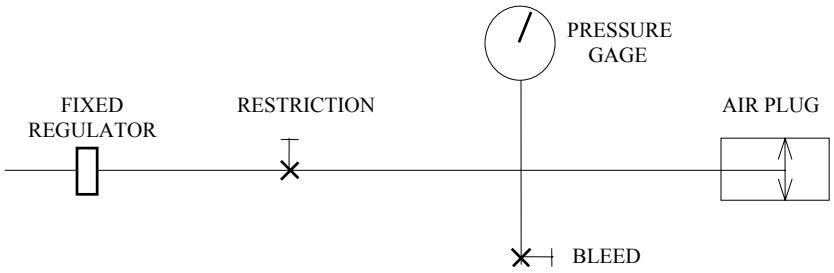


Figure 7 Backpressure Dial Type System

<u>Characteristics</u>

1. The high-pressure unit cleans the light film of oil from the piece part and insures a good reading.
2. The orifices and needles are readily accessible and may be cleaned if an oily air line is used.
3. The system has a fair linearity.
4. The magnification on the units is adjustable within very broad ranges, so that tooling is not necessarily single purpose.
5. The gages will accept almost any brand of air tooling, and although the gage may not be linear, it can at least be set to two master rings for the tolerance spread.
6. The unit uses two masters, which are easily traceable.
7. The response is good.
8. A long hose slows down the meter movement so it may not be useful in measuring long bores.

9. Will use almost any nozzle size up to about .070". This is very helpful when small nozzles are required to check narrow lands.
10. Many manufacturers make tooling for bleed circuit type gages so the customer is not tied down to one manufacturer, as with the differential type unit.

B The Flow Type

The diagram of the flow type system is shown in Figure 8. This system has a very good range of magnifications, which are available by use of interchangeable flow meter tubes. The magnification and the zero position of each tube are set by means of the two control knobs and the use of two master rings.

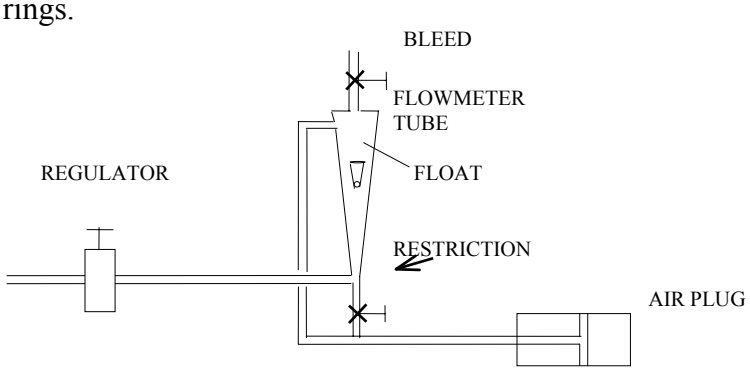


Figure 8 Flow Type System

Characteristics

1. The reading is shown in the tube by means of a float carried up and down by the varying airflow.
2. The system is low pressure, operating at about 10 PSI.
3. The system needs large nozzles to get good readings and, as smaller nozzles are used, the amplification is decreased. When very small nozzles are used, the air signal is fed into an auxiliary amplifier, which is in fact a backpressure system operating a nozzle, in turn operating the flow tube.
4. The columns are very good for multiple dimension reading where they can be stacked in parallel lines.
5. The allowable change in nozzle clearance on the air plug is comparatively low so there is a rather poorer wear life in this system compared to some of the others.
6. The tubes tend to accumulate a little oil when used under bad air conditions and require fairly frequent cleaning if the conditions are bad enough.
7. The system can be used with very long hoses and the hose length does not affect the reading. This is very good for checking long gun barrels, etc.
8. The system is relatively inexpensive, and a very good modular design exists.
9. The two masters that are used make for easy traceability.

C The Differential System

The diagram of the differential system in its present form is shown in Figure 9. In this system, the air is supplied through a regulator. The stream is divided and flows through two fixed orifices (jewels). One side of the system is used as a zero valve and the other side is used to operate the gaging member. The difference between these two legs is measured by means of a bellows system operating what is a modified type of dial indicator or uses an electronic bellows for digital readout. This type of system is best used where the exact deviations of the readings need to be known and they must be accurate.

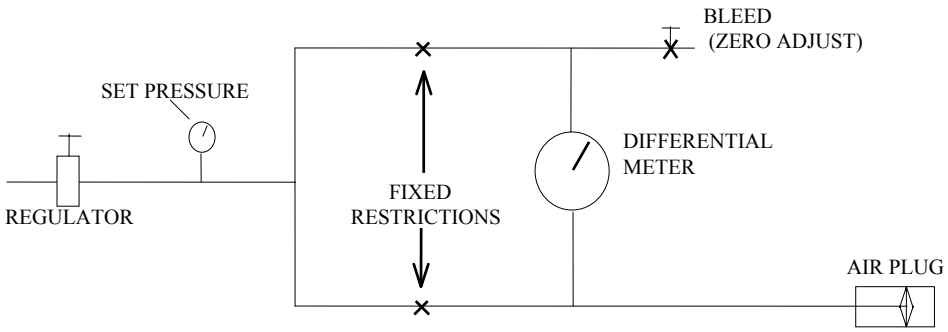


Figure 9 Air Differential System

Characteristics

1. Uses one master and is very easy to set up.
2. The response time is quite good.
3. The magnifications are fixed and the tooling must be ordered for each particular magnification, they're being no adjustability in the system.
4. System accuracy depends on the fixed orifices. If they were to oil up or be damaged, the unit would have to go back to the factory for repair.
5. If the orifices are clogged in any way or the plug member has been damaged by means of setting with one master, you would not be sure that you had the correct magnification, and a part being measured near the end of the tolerance would not necessarily be the size shown. It would, therefore, appear best to use a system with two masters.
6. The question of traceability comes up. With two masters a system is readily traceable by means of readings taken ability of this one master system you have to use the traceability of the reading on the zero ring plus a traceability of a magnification setting unit to check out the gage itself.
7. The system is not very susceptible to supply pressure changes.
8. Operates on medium-high pressure and is probably satisfactory for cleaning light oil films from the parts to be checked.
9. Greater clearance eliminates much of the wear caused by the plug body frequently contacting the surface (walls) of the part. This wear will not effect Magnification.
10. Greater approach range for measuring parts as they are being made which is useful for determining how much material is to be removed.
11. Allows for deeper recessed jets that help reduce wear or clogging.
12. Excellent stability. Reading does not drift after being set.

IV CONCLUSION

This sums up the number of gages that are on the market. It should be understood that they all have their good and bad points. When used under normal operating conditions and operated with good tooling from reputable manufacturers, they will give excellent results checking I.D.'s with air plugs and O.D.'s with air rings. Also, for any application that involves tolerances of less than .002" on a production basis, the use of some air gage should be seriously considered so that the operator may readily see the size of the part that he is producing, preferably when it is still in the machine tool.
We have only covered the basics of air gaging and the air plug. The same principles can be used for many other applications, some of which are listed below.

1. Multiple nozzle plugs for average I.D.
2. Rings to gage O.D.'s and lobing.
3. Plugs to check straightness of bores.
4. Plugs to check squareness of bores to face.
5. Fixtures to check concentricity of I.D. to O.D.
6. Plugs and rings to measure taper

Many applications and variations of the above list are possible and, in most cases, will require special fixtures. A Mahr Federal Inc. specialty is in air gaging which cover most types of dimensional measurement of applications. We can supply a wide range of air tooling, which can use any back pressure, flow or balanced air gage readout.