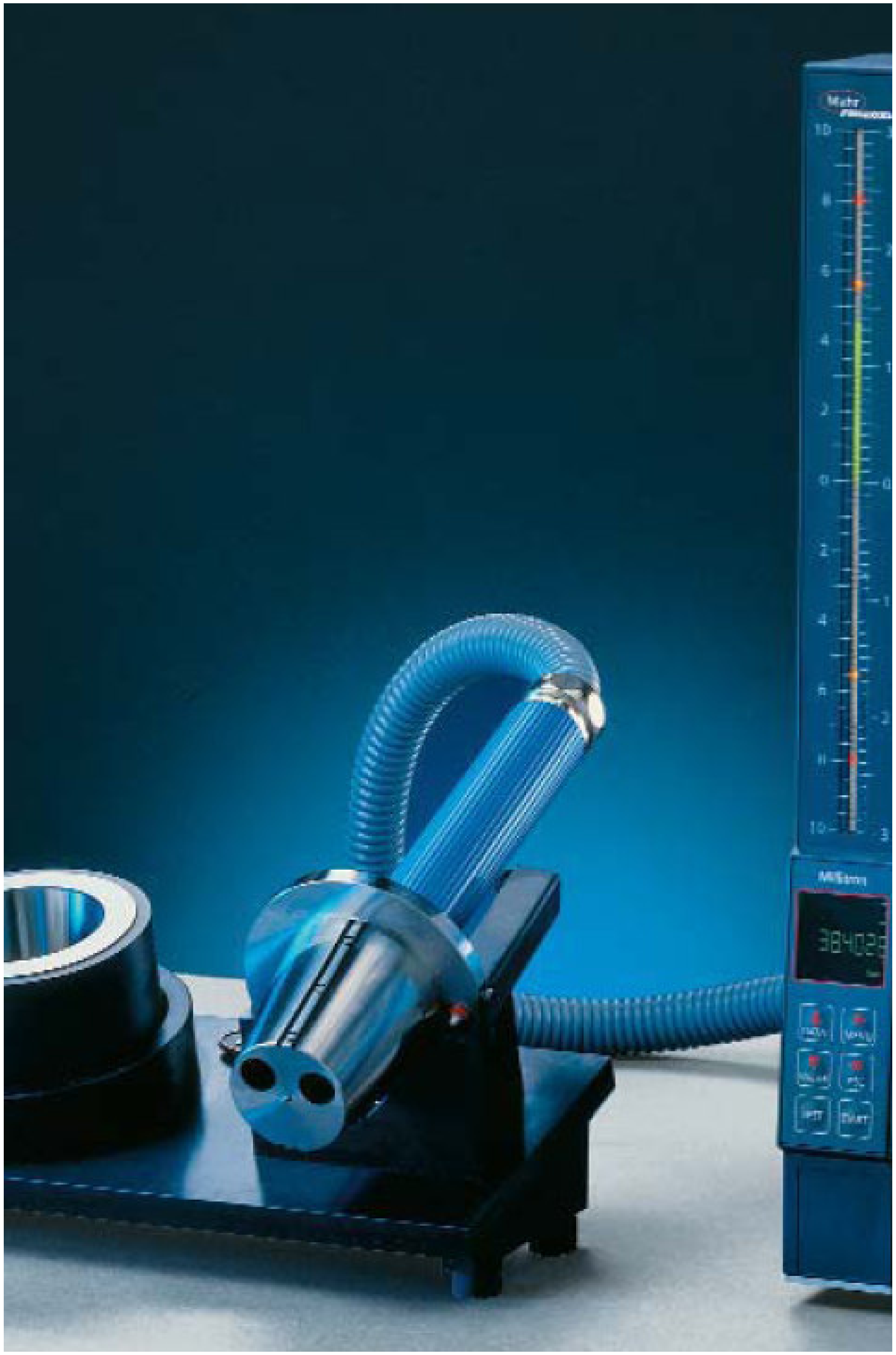

Air Gaging Basics

Willrich Precision Instr. Co
Phone: 1-866-WILLRICH
(866-945-5742)
email: sales@willrich.com

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Air Gage Basics

- Objectives
  - To provide an understanding of air gage theory
  - To learn some of the applications for air gaging
  - To understand basic troubleshooting, maintenance and verification procedures

Why Air Gaging?

- Air gaging is a measuring system that
  – Allows for fast measurement
    - Self aligning
  – Provides high resolution
    - Performance to 0.1um/5u”
  – Easy to use
    - Little operator skill involved
  – Is non-contact
    - Won’t mare the part
  – Self-Cleaning
    - Air blows away surface contamination

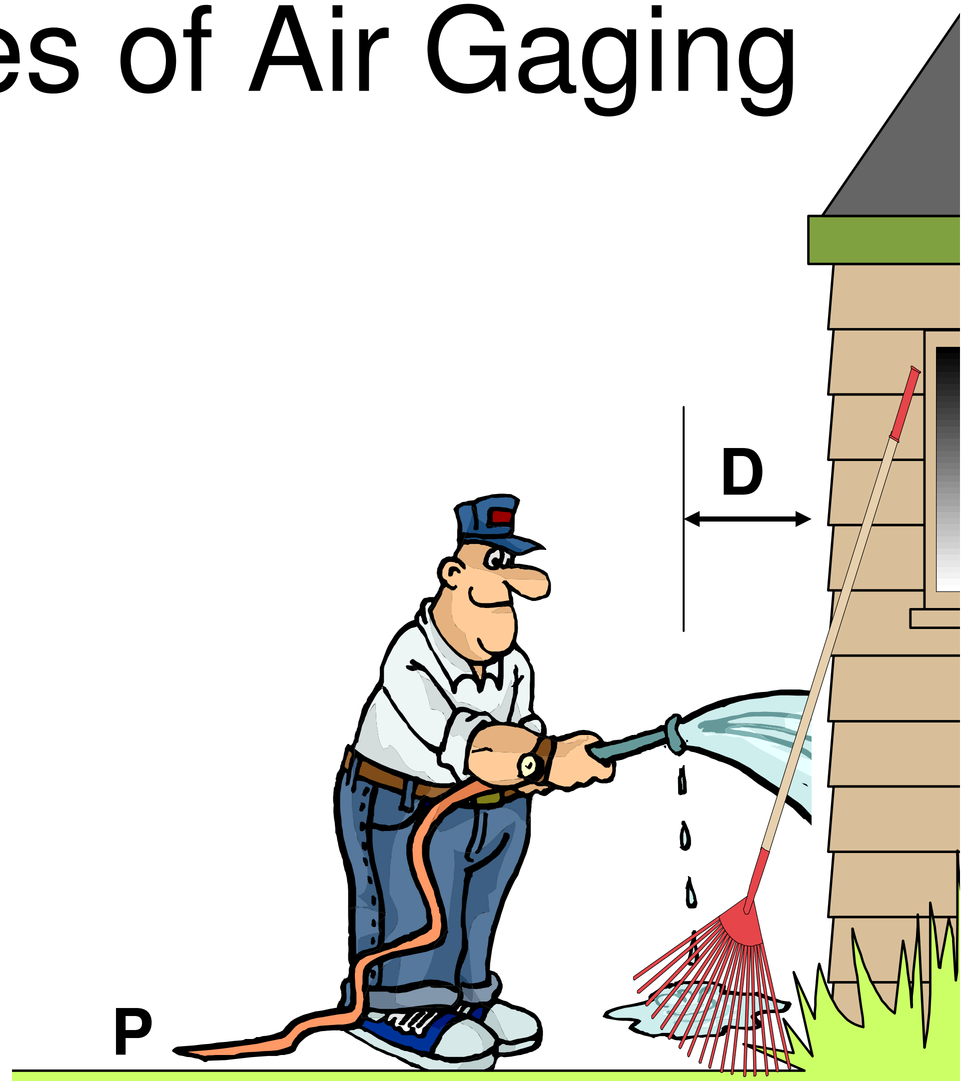
When to use Air Gaging?

- Have a tight Tolerance condition
  - <± 40um / ± 0.0015”
- Know when a part is good or bad
  - Know the variation from the nominal
- Have a high volume of parts to measure
  - Measure quickly with min operator influence
- Or – have a geometric measurement –
  - maybe not of high volume but where alternative measurements (ie CMM’s) are too time consuming
    - Taper.Straightness/Center Distance
- Environment is dirty

Principles of Air Gaging

Just like a garden hose – as the distance D gets smaller and restricts the water flow – pressure builds up in the hose. What can you say about the flow of the water as the distance is changed?

Water and air act very similar!



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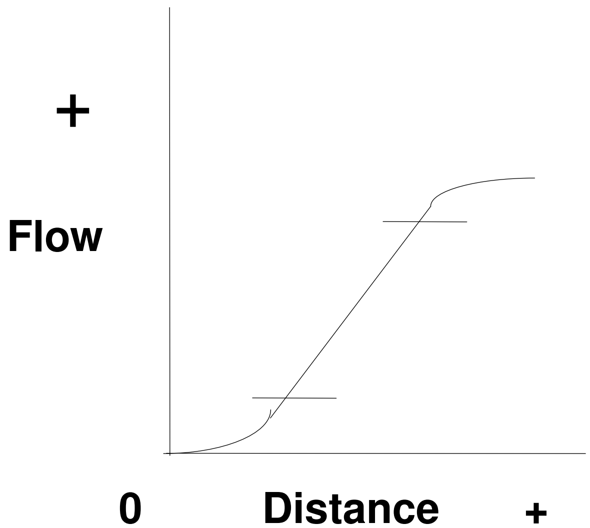
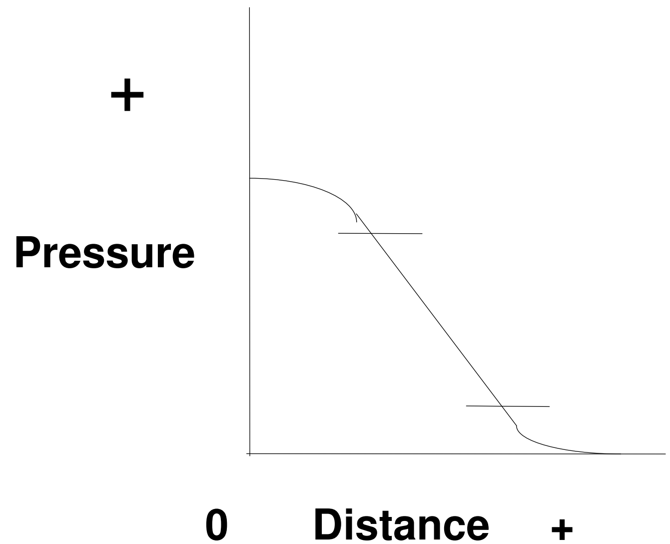
What’s Happening with Flow and Pressure



Flow increases as the distance between the nozzle and restriction increases



Pressure increases as the distance between the nozzle and restriction decreases

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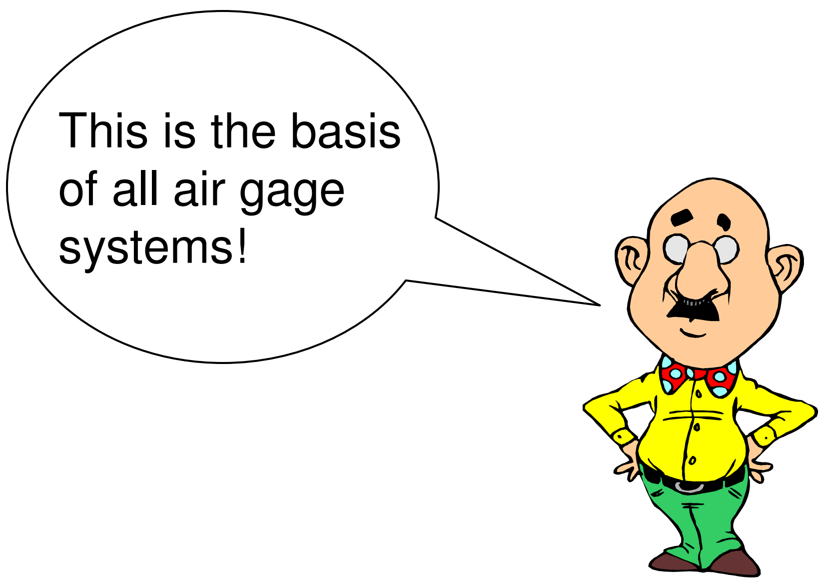
Fortunately these curves are very repeatable and the data can be used as a means to display a dimensional measurement!



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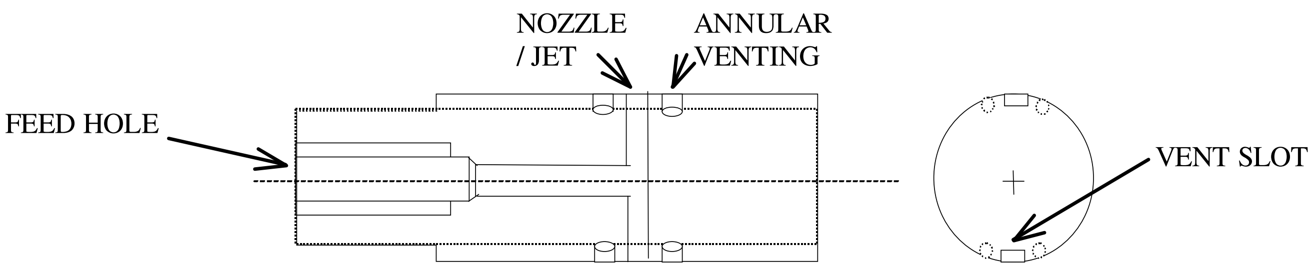
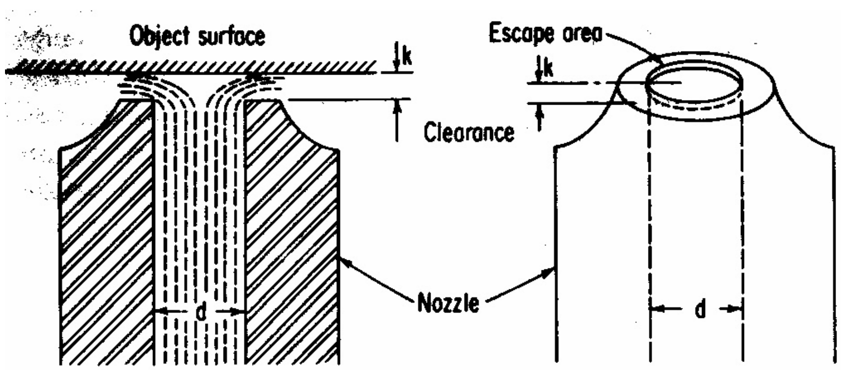
The pressure distance curve are dependent on the “jet” which the air flows through.



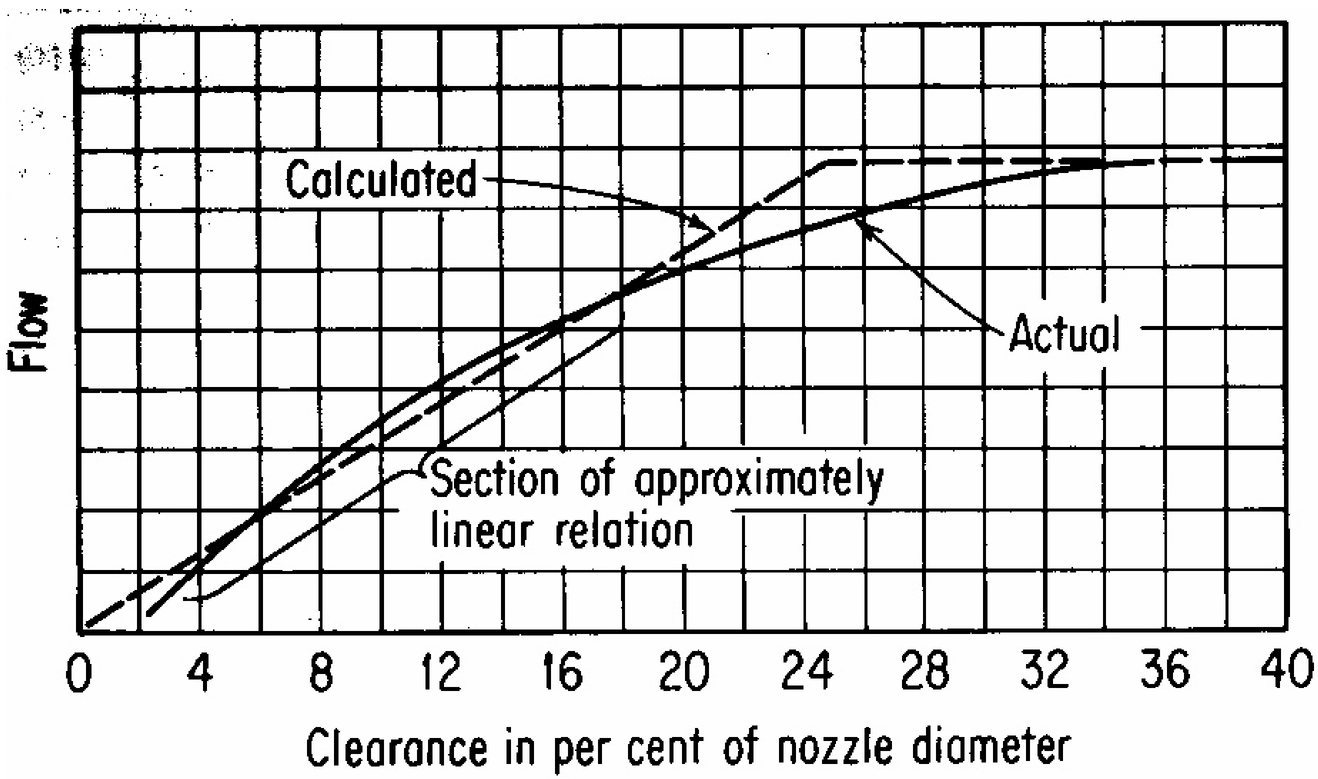
An Air Tool holds these nozzles in a precise steel cylinder or ring.

Cross section of Jet

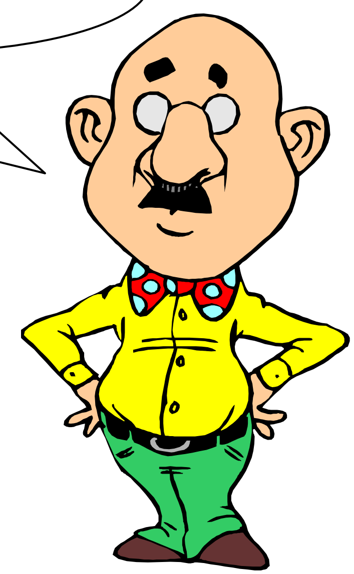
- An air gage works by impeding the flow of air through the jet at a rate which is proportional to the size difference of the dimension being measured



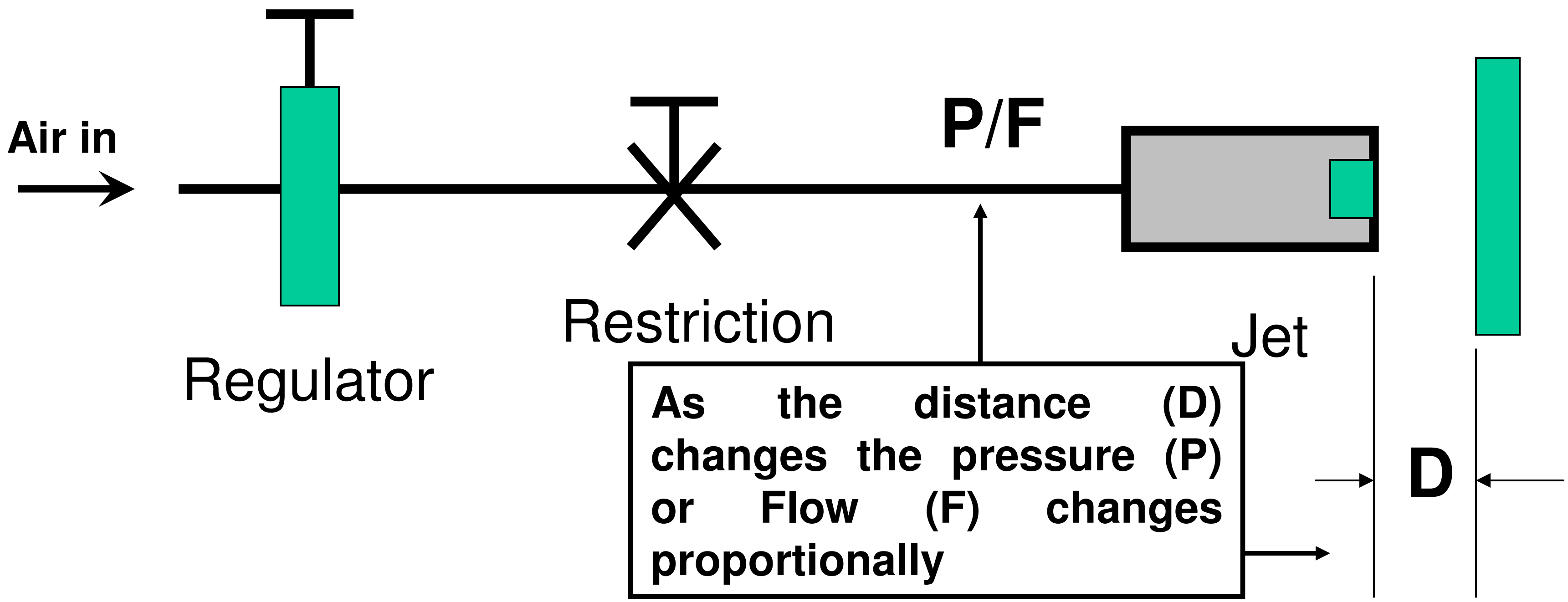
Actual Plot of Curve
Not exactly linear but very close



There are two basic types of Air Gages - Flow and Pressure – with Pressure being the most common



All air gaging consists of these minimum parts



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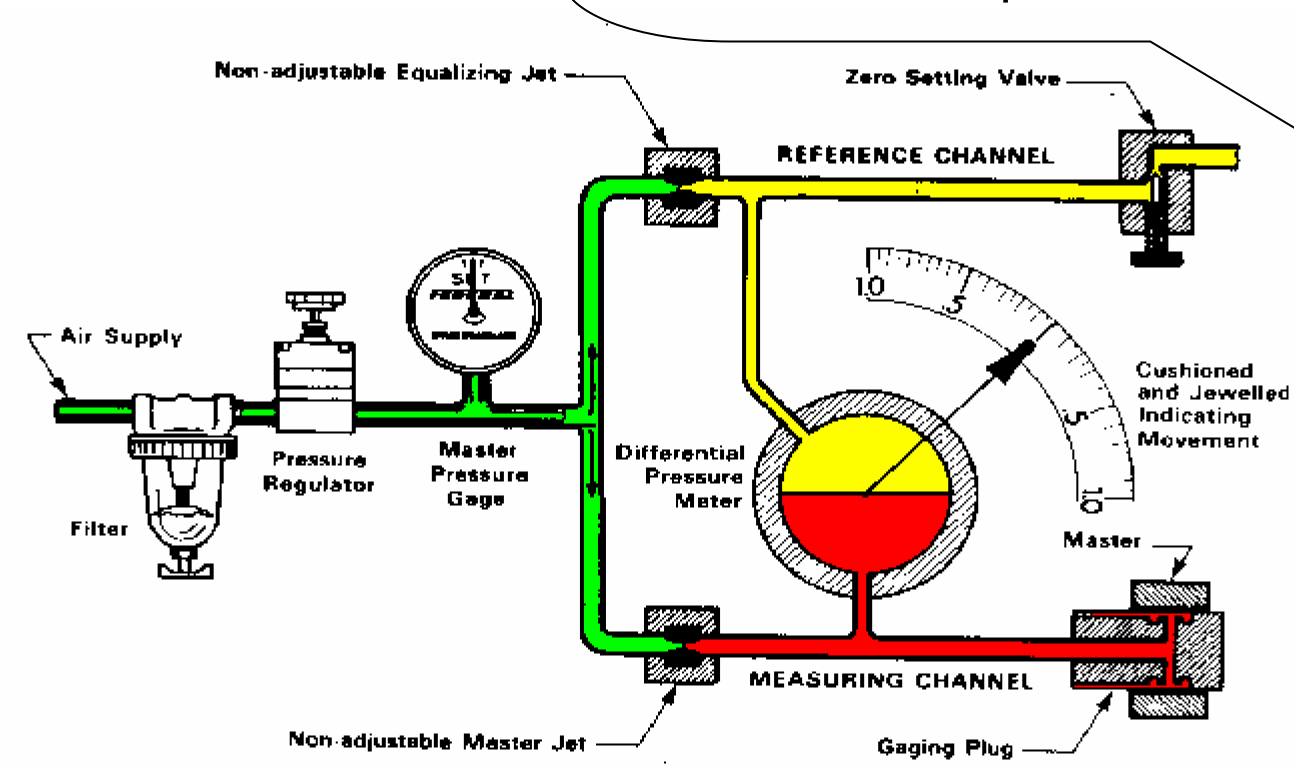
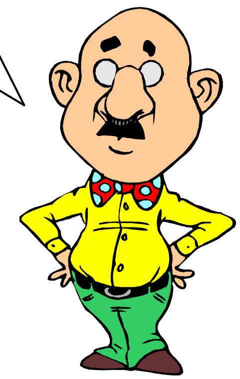
Mahr Federal primarily uses a Balanced Air System

In this system the air is broken into two lines – one acts as a reference and the other does the measuring. This actually measures the difference between the two pressures.





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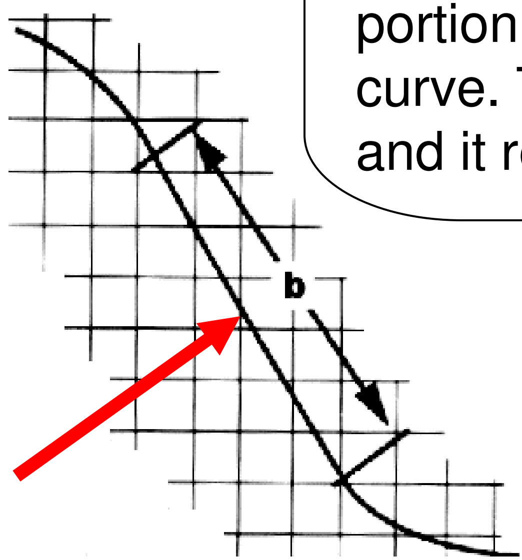
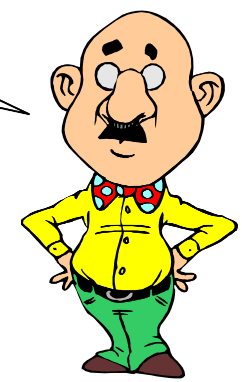
Key factor of a Balanced Air System

Because the balanced system is manufactured to high standards - it is made to place the “zero” point very close to the center of the linear portion of the pressure distance curve. Therefore linearity is known and it requires only one master.





Balanced System Characteristics

- One master very easy set up
- Fixed magnifications – no adjusting
- Accuracy depends on fixed orifices
- Not susceptible to small pressure changes
  - Excellent stability – readings do not drift after being set

Balanced System Characteristics

- Good speed of response
- Uses medium/high pressure to clean parts
- Recessed jets - means longer tooling life
  - Does not effect magnification
  - Can reduce clogging
- If orifices are clogged, magnification can change

The Air Tooling Clearance

- Clearance allows for getting the part into the gage easily – while minimizing error
- Air Tool clearance - typically .0018” *
  - As accuracy requires increases - less clearance and less measuring range
- Centralizing error - increases as air tool clearance increases (typically from wear)

* Plug range will change this

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Plug Clearance / Jet Clearance

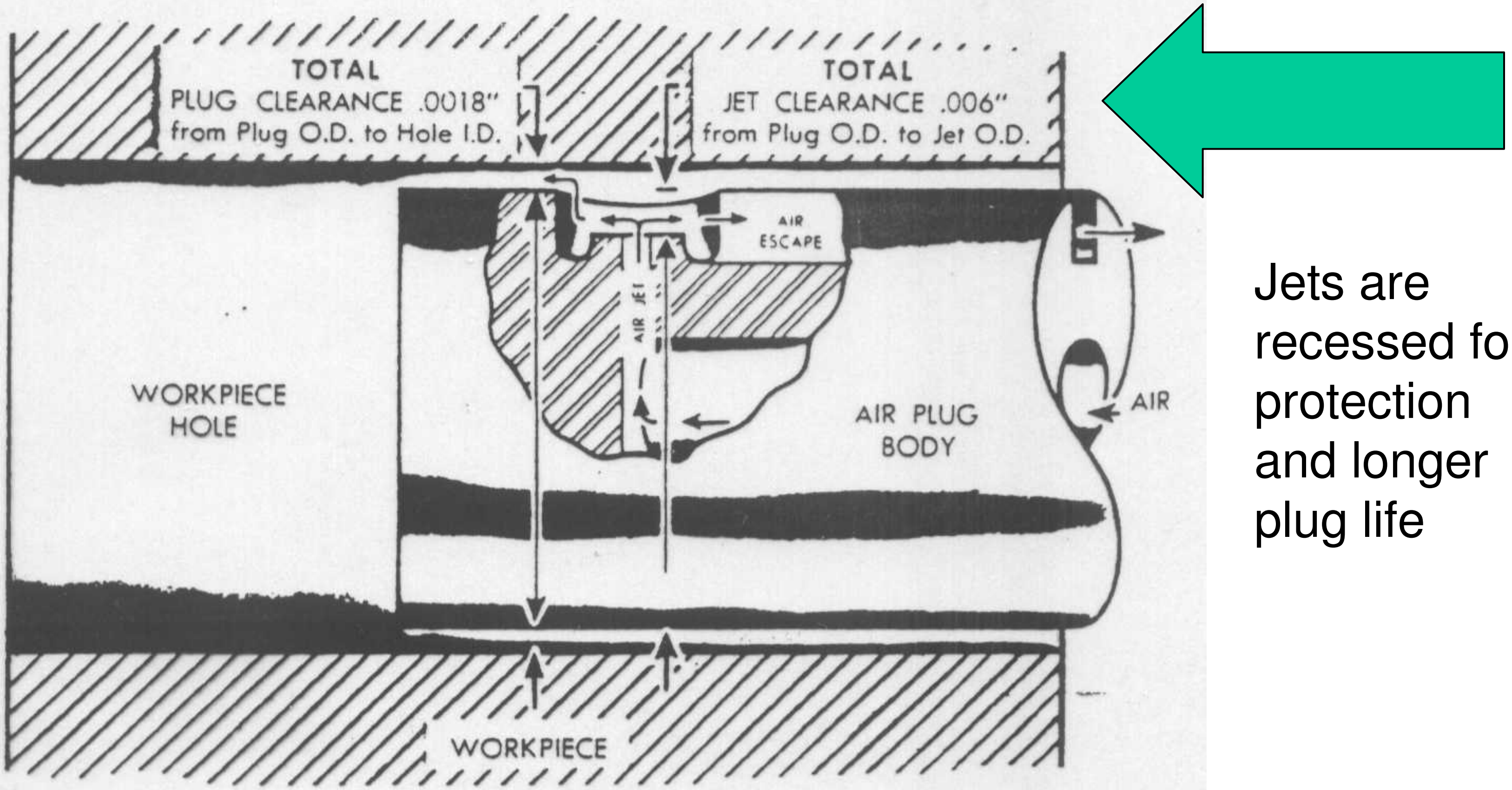
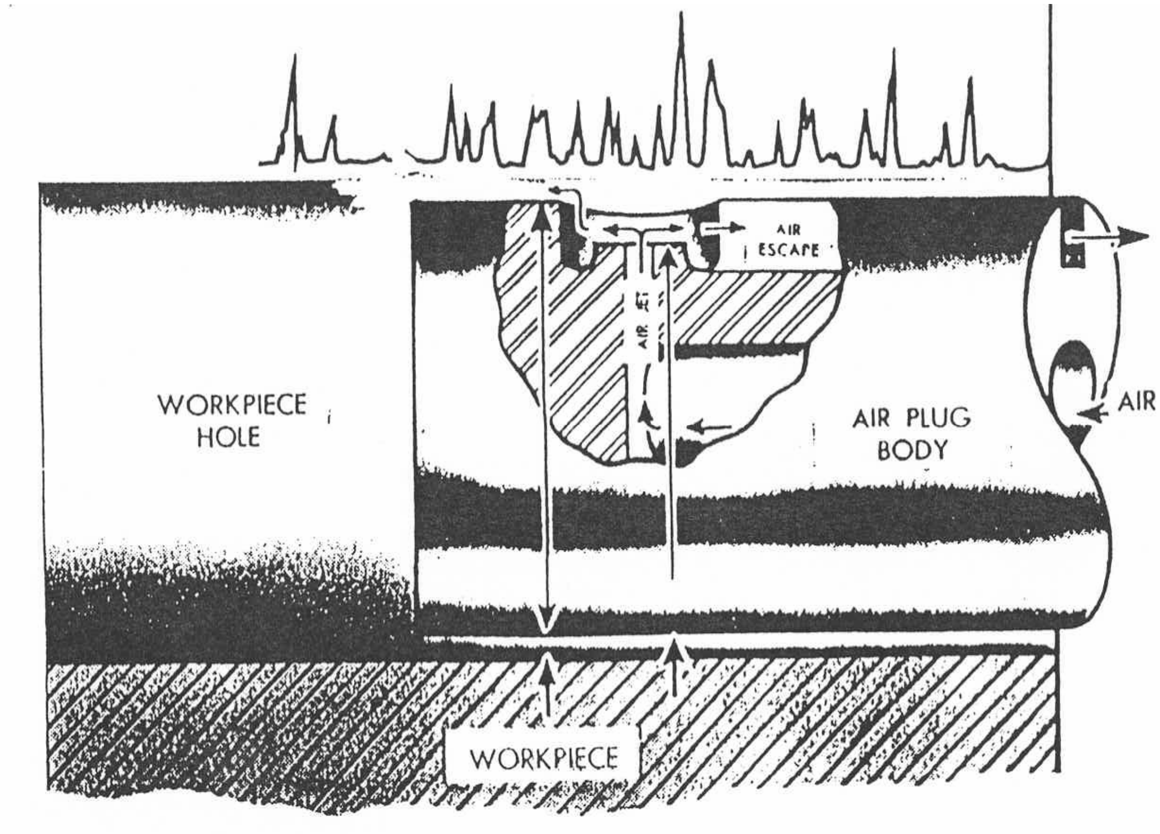


FIG. 1

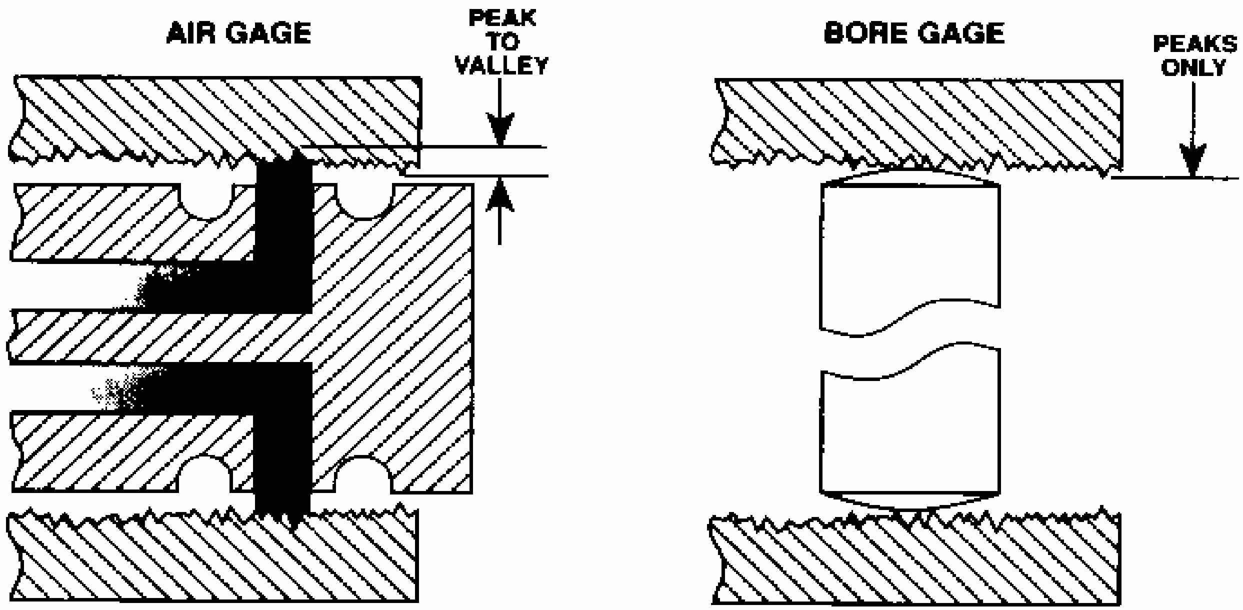
Jets are recessed for protection and longer plug life

Why is surface finish important?



- The measuring area is fairly large
- Acts as an averaging measurement
- Correlation to other gaging methods

What is the true size?



An air gage averages a measuring area

A mechanical contact gage is a point contact system and measures the high points

Application – Taper Angle

- Taper is controlled by diameter size and angle.
- Size is controlled by a tolerance – just like an ID/OD
- Taper can be controlled by three different methods
  - Included angle or angle per side
  - Taper per inch or per foot
  - Controlling two diameters at specified locations

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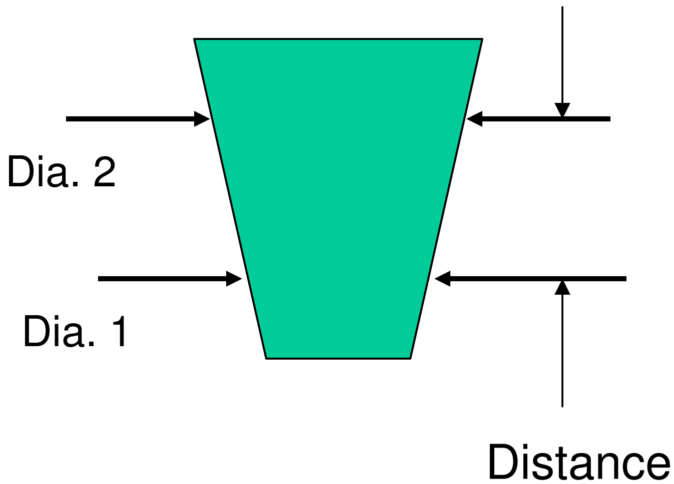
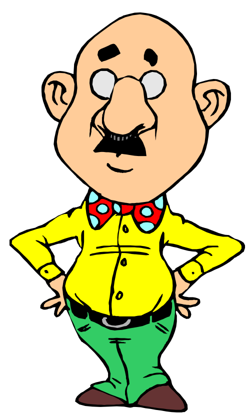
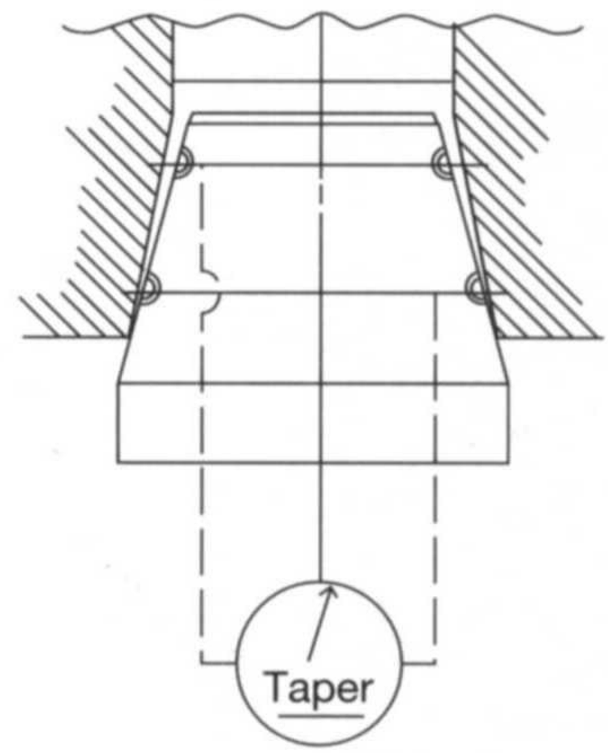


In all cases air gaging uses two diameters – at a known distance apart -to perform a differential measurement – Air tooling is made to measure these conditions in one of three ways

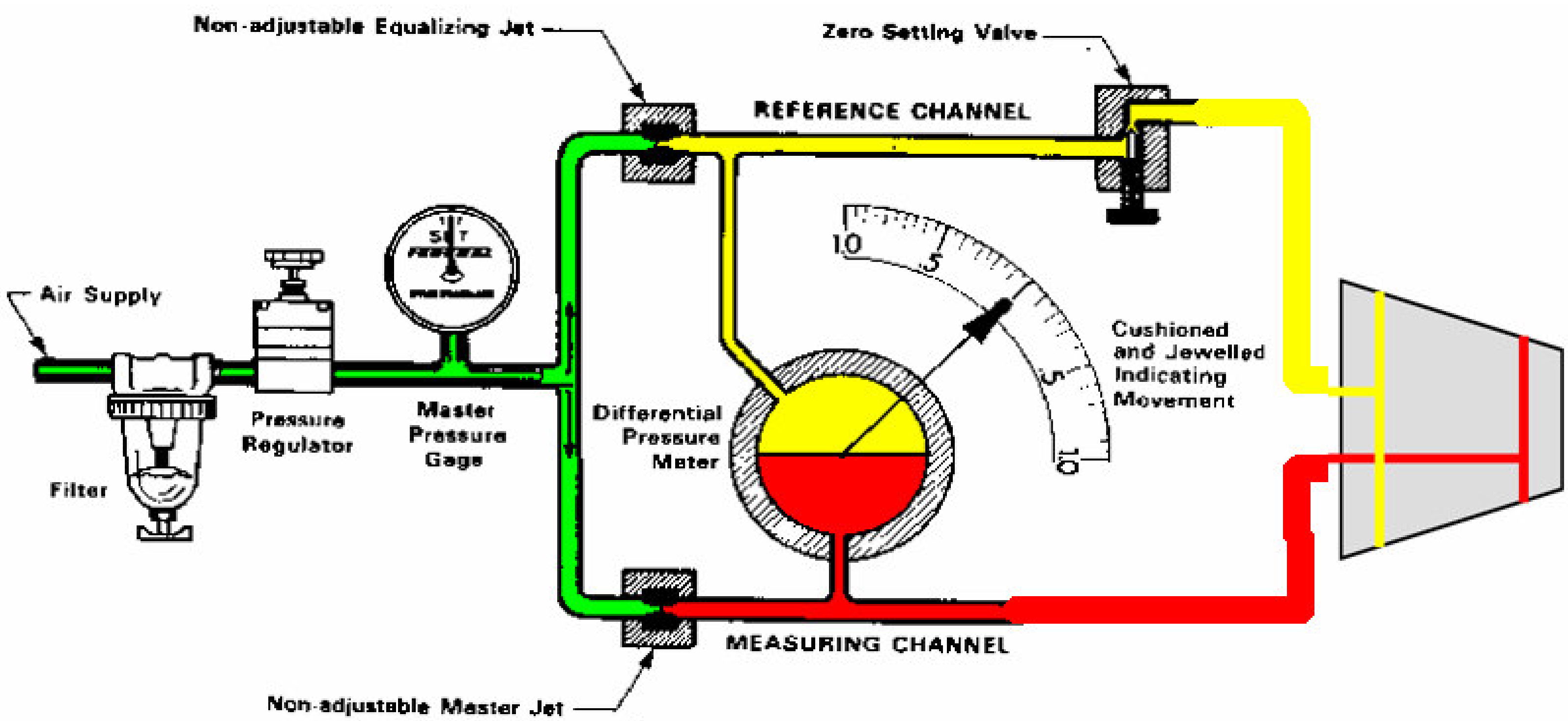


Jam Style Taper Tooling

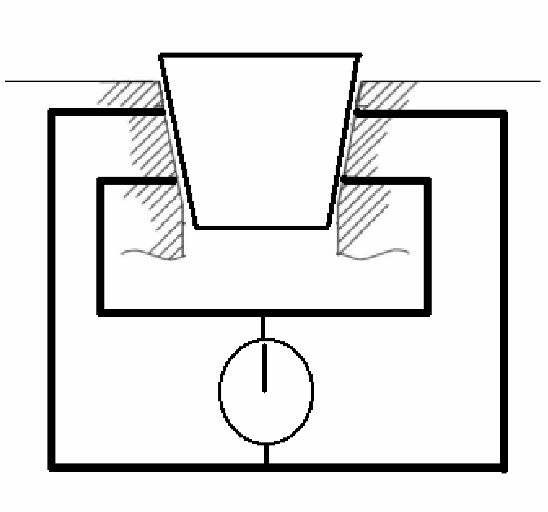
- Provides only information about the taper angle
- Does not provide diameter information
- Differential measurement
- Used on parts with no shoulder or controlling face – does not matter how far the mating part drops into the taper.
- - Jets are recessed more so that pneumatic zero is at no clearance- this will be addressed later



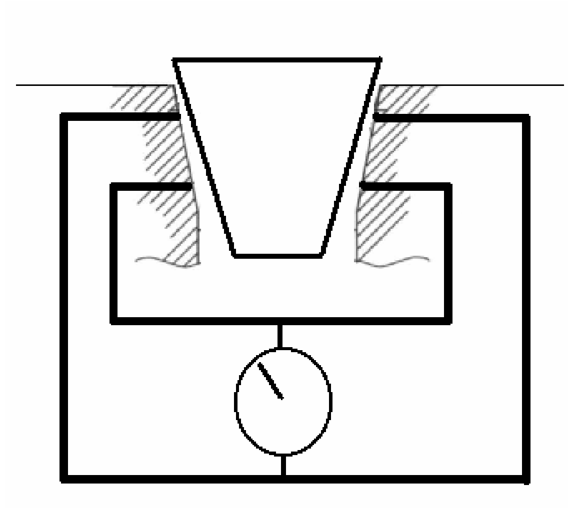
How a Differential Air Display is configured



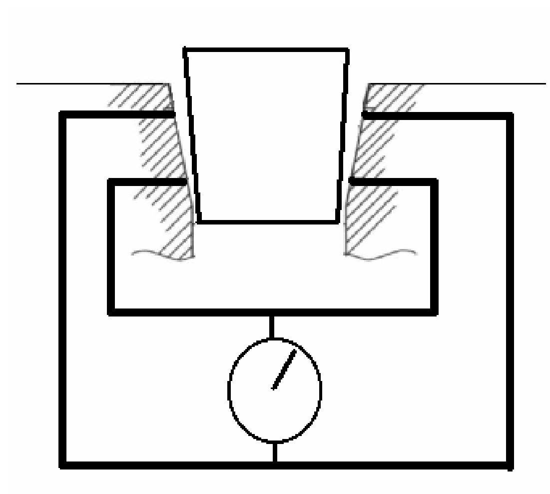
Reading the Differential Taper



Upper set of air jets and lower set of air jets in air ring see the same back pressure. Meter on Dimensionair reads zero



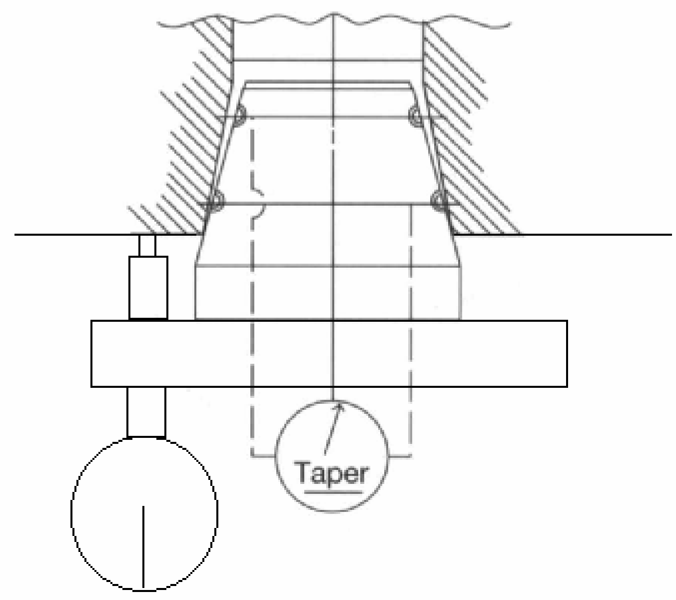
Upper set of jets see more back pressure then lower set. Meter on Dimensionair indicators larger taper angle



Lower set of jets see more back pressure than the upper set of jets. Meter on Dimensionair indicates smaller taper angle

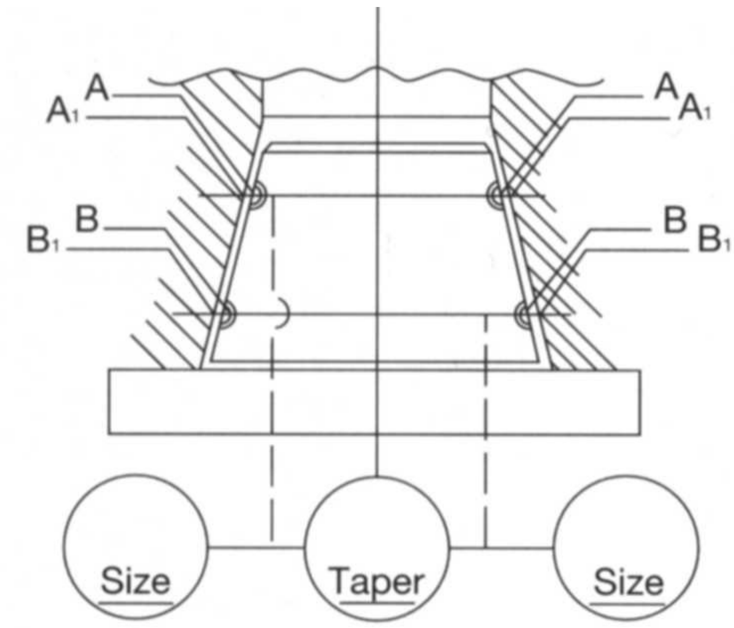
Modified Jam Style Taper Tooling

- Provides only information about the taper angle
- Does not provide diameter information
- Differential measurement
- Indicator provides height information – (how far plug goes into part) – provides acceptable limit about size

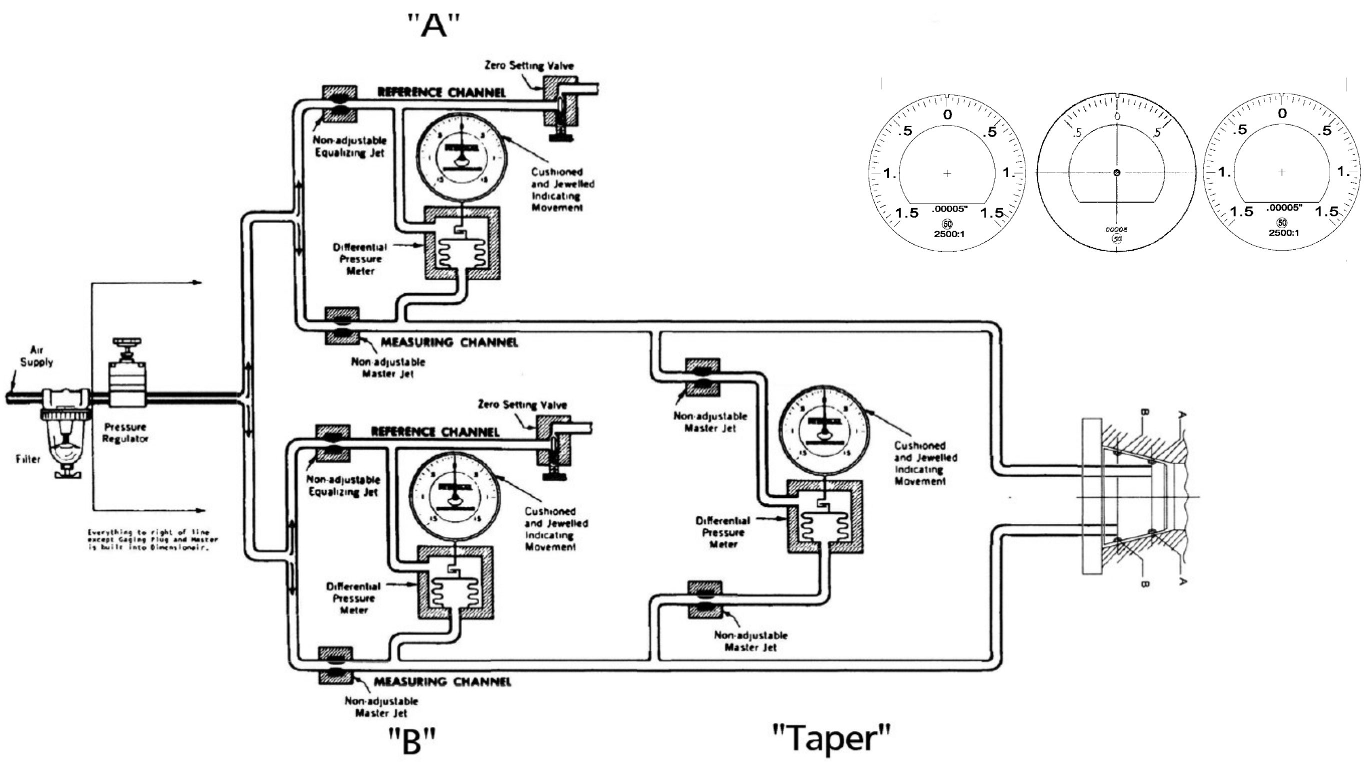


Clearance Style Taper Tooling

- Provides information about the taper angle
- Provides diameter at two or more locations (potential to measure straightness) (bell/mouth/hourglass with a third set of jets)
- Differential measurement of two of more independent diameters



How an Air Display is configured to show two diameters and taper



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What types of gages does Stryker employ?

- Two station gage – one for diameter as a location and one for taper only (jam style)
  - Uses a diameter and differential display
- Single gage for two diameters and Taper – Clearance style
  - Uses three meter display of two diameters and differential display

Monitoring to achieve good gaging

Excessive plug wear can produce the following conditions:

1. Reduced body diameter increases plug clearance and produces centralizing error.

2. A change in jet diameter or jet orifice size, shape or condition can cause a shift in pneumatic zero.

3. The air flow characteristics of each jet are different causing a balance error.

Therefore to monitor plug wear the above three conditions have to be checked.

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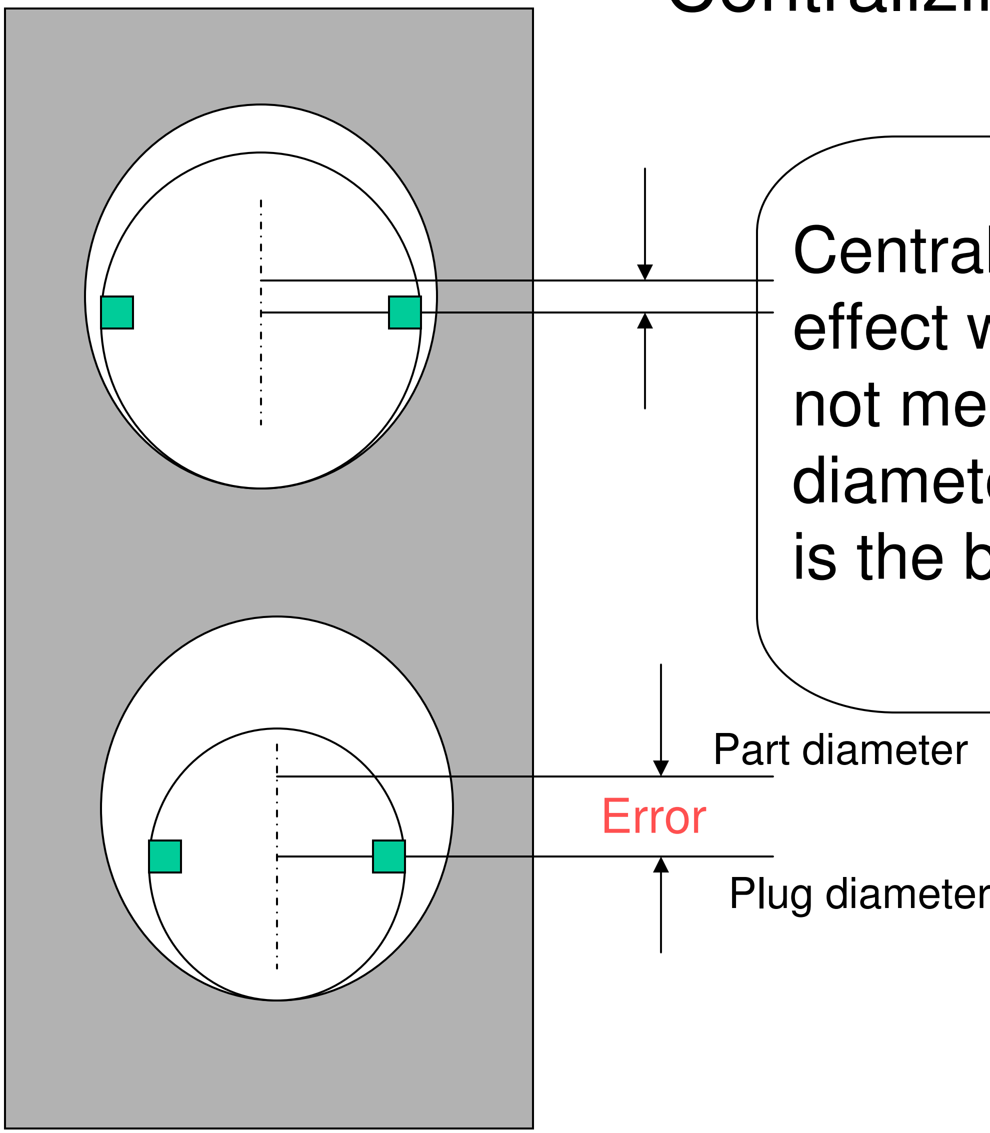
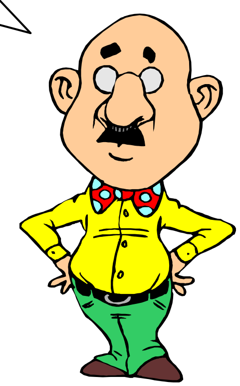
Centralizing Error



Centralizing error is an effect where the plug does not measure the true diameter of the part – wear is the biggest contributor



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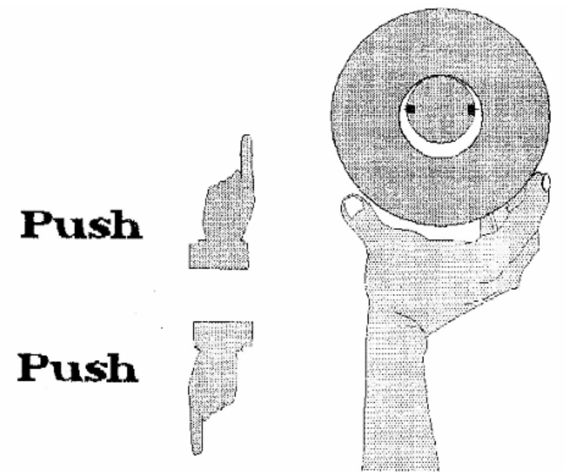
Monitoring Centralizing error

One method of determining centralizing error is to use an appropriate master [Zero Master]

Mount tooling and master to the Dimensionair, with the jets in a Horizontal position, set meter to “Zero”

Move the master vertically on the plug, note the shift in the readings.

This is the centralization error for this Air Tool and Master.

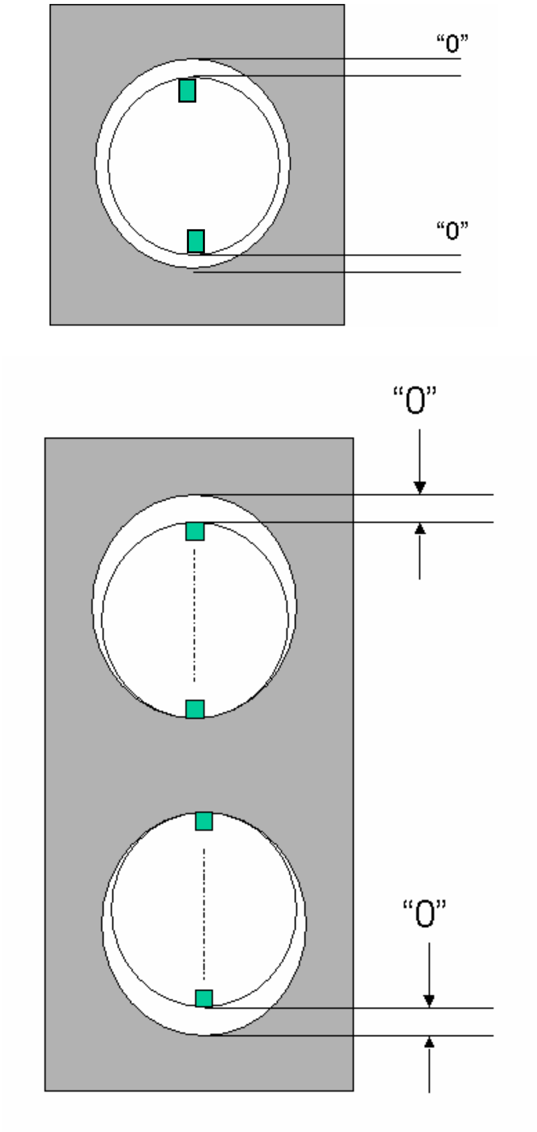


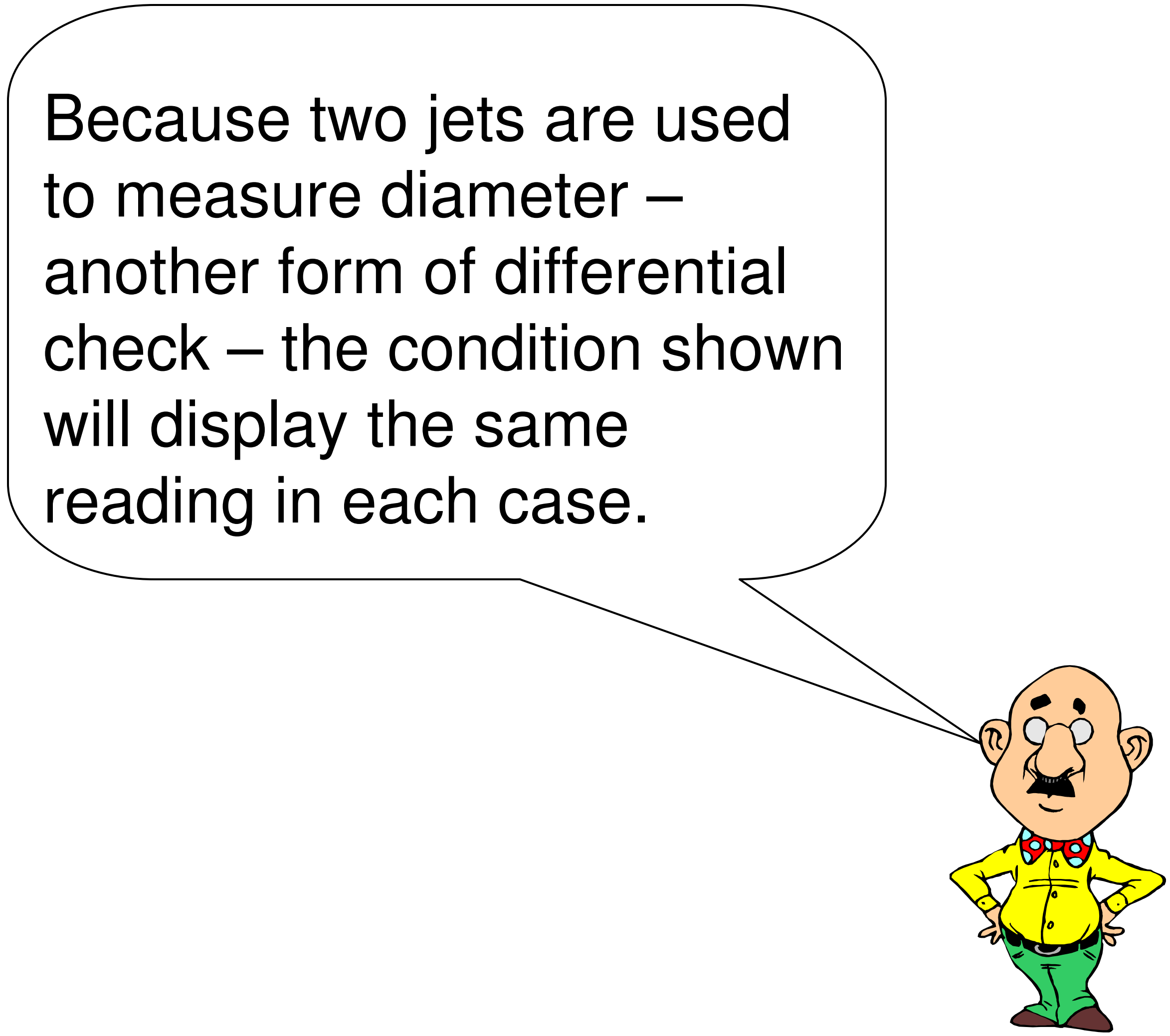
Monitoring Centralization Error

New tooling is sized to have a clearance that will limit centralizing error to less than one division on the dial.

Centralizing error on used tooling should not exceed 10% of part tolerance.

Differential Check – Balance Error





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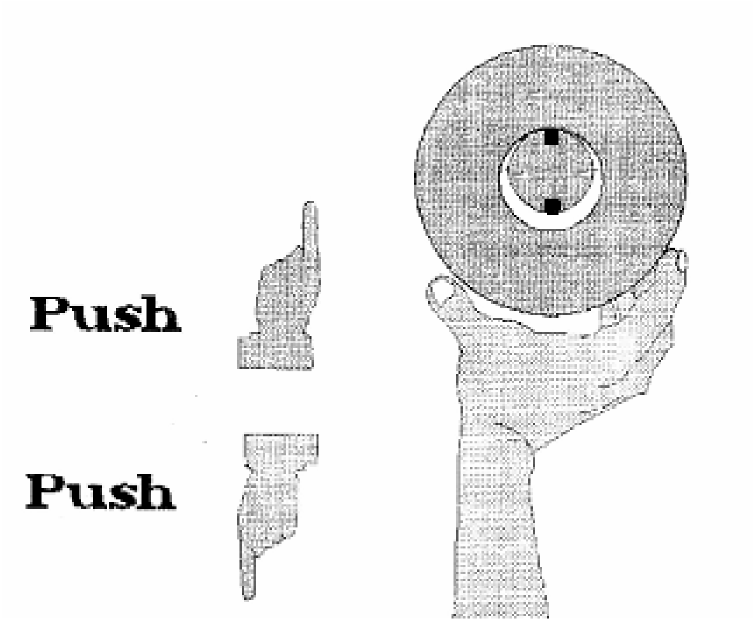
Reasons for Balance errors

- Wear – when wear becomes so bad it wears the face of the jet
- Inadvertently pushing in an inserted jet
- Orifice damaged
  - During cleaning
  - From dirt
  - Crack or burr

Monitoring Balance Error

This condition can be checked by using the same method as noted above for centralizing error except position jets in a vertical position and move the master up and down on the plug. Any deviation in readings is balance error. In general, balance error should not exceed 50u”. In no case should total of centralizing plus balance error exceed 10% of part tolerance.



Zero Shift

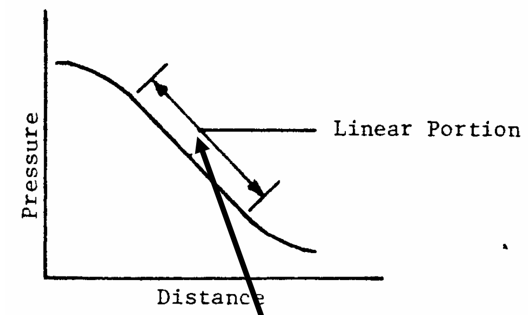
New tooling is made to the following pneumatic zero.

	Right	Left
D-2500 to D-8000	.000l5”	.000l5”
D-10,000 to D-32,000	anywhere on scale is acceptable	

Worn tooling should be monitored to compare tool zero position compared to the zero position on the Dimensionair. This is done by comparing the reading of a zero restrictor with the tooling under test with its certified zero master

Monitoring Zero Shift

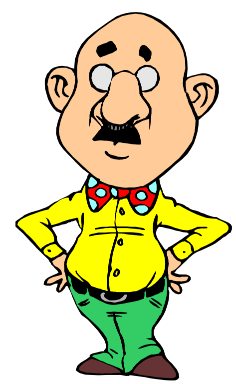
Place the zero restrictor, as normally used, on the front of the Dimensionair or end of hose.



Set zero on Dimensionair by adjusting the zero setting knob.

Tooling is built to place it's manufactured zero at the midpoint of the pressure distance curve

Replace the zero restrictor with the air tooling to be checked and place master on/in the air tooling so that the jets are at the approximate mid-point of the master. Without any adjustment of the zero adjustment knob, the hand on the Dimensionair should fall within the limits specified on the following chart.



Acceptable Limit Table

DIMENSIONAIR	MEASURING SIZE		ACCEPTABLE LIMITS	
D-2500/D-4000	.123" - .140"	Left	.0003"	Thru Right .0005"
D-2500/D-4000	.140" - .185"	Left	.0005"	Thru Right .0005"
D-2500/D-4000	.185" - .248"	Left	.0007"	Thru Right .0005"
D-2500/D-4000	.248" - UP	Left	.001”	Thru Right .0005"
D-5000/D-8000	.123" - .140"	Left	.00015"	Thru Right .0005"
D-5000/D-8000	.140" - .185"	Left	.00025"	Thru Right .0005"
D-5000/D-8000	.185" - .248"	Left	.00035"	Thru Right .0005"
D-5000/D-8000	.248" - UP	Left	.0005"	Thru Right .0005"
D-10000/D-16000	.062" - UP	Left	.0003"	Thru Right .0003"
D-20000/D-32000	.062" - UP	Left	.00015"	Thru Right .00015"

Excessive reading to right on dial is caused only by contamination and air tooling should be re-cleaned.

Readings to left of acceptable limits indicates potential dial readings beyond the linear portion of the P.D.C. and air tooling should be reworked or replaced.

Inspecting Jam Style Tooling

- Jam style tooling does not have the normal clearance built into it
  - The jets are recessed more to place pneumatic zero at interference location
  - Therefore centralizing error or balance test are not applicable
  - Zero Shift test is used to inspect for wear or balance error

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Testing for Zero on Jam tooling

Required – the appropriate restrictor kit with two zero masters

- Place a zero restrictor on each of the channels on the differential Dimensionair and adjust the unit to "zero"
- Replace one of the restrictors with a channel from the air tooling – monitor zero position and compare to chart
- Repeat using the second channel and monitor zero position and compare to chart

Inspecting Masters

It's possible to use qualified gages to compare Reference masters to Working masters

- Use Reference master to verify gage and set to pneumatic zero
- Replace with working master
- Note difference – and compare to your acceptable limit – 10% part tol?

Using Master Deviation

- Although the goal is to make a perfect zero master – no manufacturing techniques are capable of doing this
- Techniques are available that can allow the measurement of masters to very high accuracies
  - For example – a diameter reading on a master may have a deviation of + 25u" (the master is 25u" larger then the nominal zero size)
- Using the Masters known error can improve the results from the gaging system
- It also can lower the cost of purchasing masters

How to Set-up gages using the Master Deviation

- Using previous example – cert shows a +25u" deviation on diameter. Using a .500" nominal size – master is actually .500025"
- Accepted procedure – place master in the gage and mechanically adjust gage dial to read zero
  - This shifts the display to read a part 25u" larger then it actually is
  - Often used when the master deviation is less then 10% of part tolerance
- Better procedure – place the master in the gage and mechanically adjust gage dial to read +25u"
  - This makes the gage read the true master value as the proper displayed size – and makes the parts read their actual size

Other topics

Mahr Federal's Primary air system is based on the Balanced Pressure circuit

- In this system we know that by controlling the pressures, jet diameters, and jet recesses, a very repeatable and accurate measurement system can be created. The accuracy is buiilt into the tooling and readout

- The data can be used as a means of displaying a dimensional measurement!

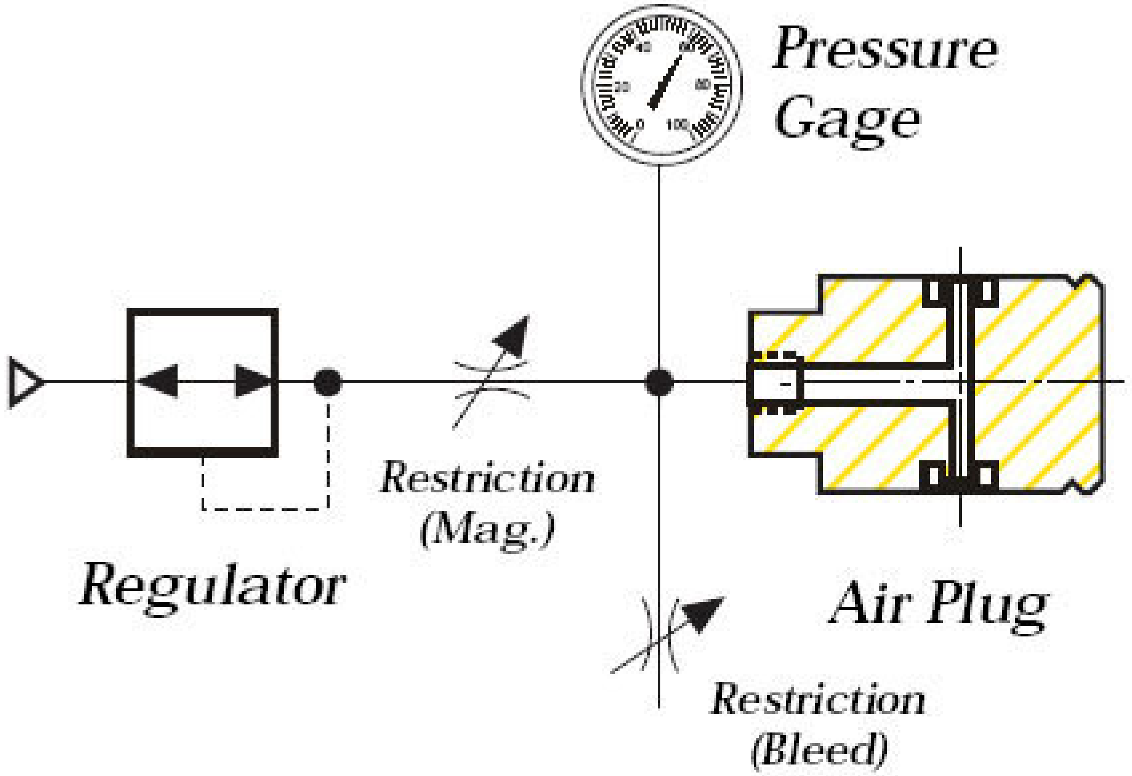
OR

With and Adjustable Magnification system

- By varying the pressure to change the system magnification to match up with the gage limits, a repeatable measurement system can be created.

  The data can be used as a means of displaying a dimensional measurement!

Back Pressure Bleed System



Back Pressure Bleed System

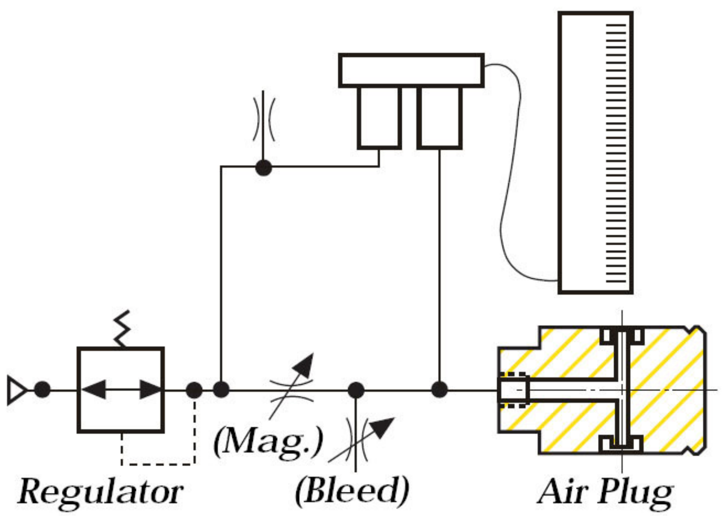
- Very versatile
  - Accepts almost any manufacturer's tooling
- Fixed regulator controls air pressure for maximum linearity
- Adjustable restrictor changes the magnification for different tooling
- Adjustable bleed changes zero location

Back Pressure Bleed System

- Has two controls for set up – zero & span
- Two masters for calibration and traceability
- Adjustable magnification can compensate for worn tooling
- Capable of accommodating jet sizes from 0.020” thru 0.093”
- Has the potential of setting the gage out side of the linear portion of the measuring range
- Additional masters add to cost and maintenance
- In mechanical systems set up can be difficult and time consuming

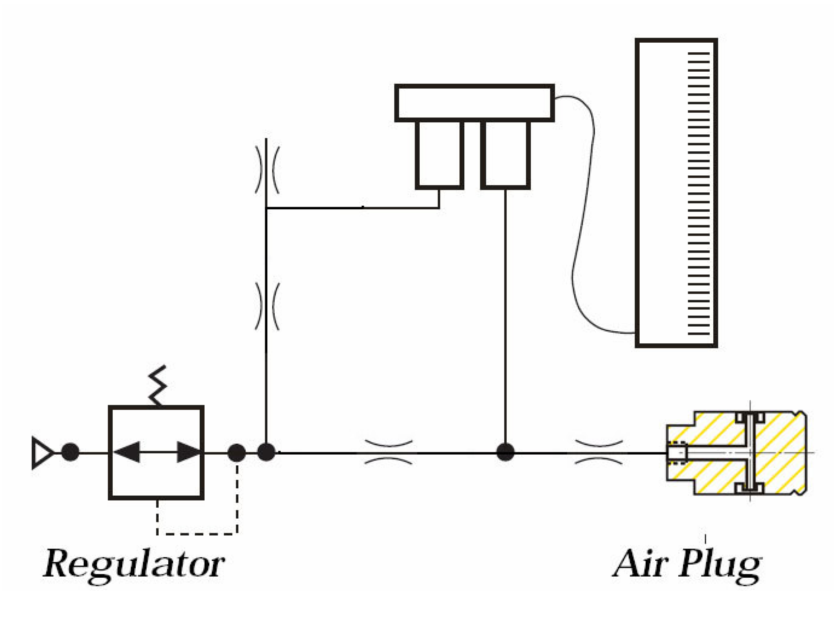
How do Electronic columns work with Single of Two masters?

Back Pressure Bleed



- Electronic transducer replaces meter
- Use mag and zero adjust to get on range
- Let processor compensate final span

Differential



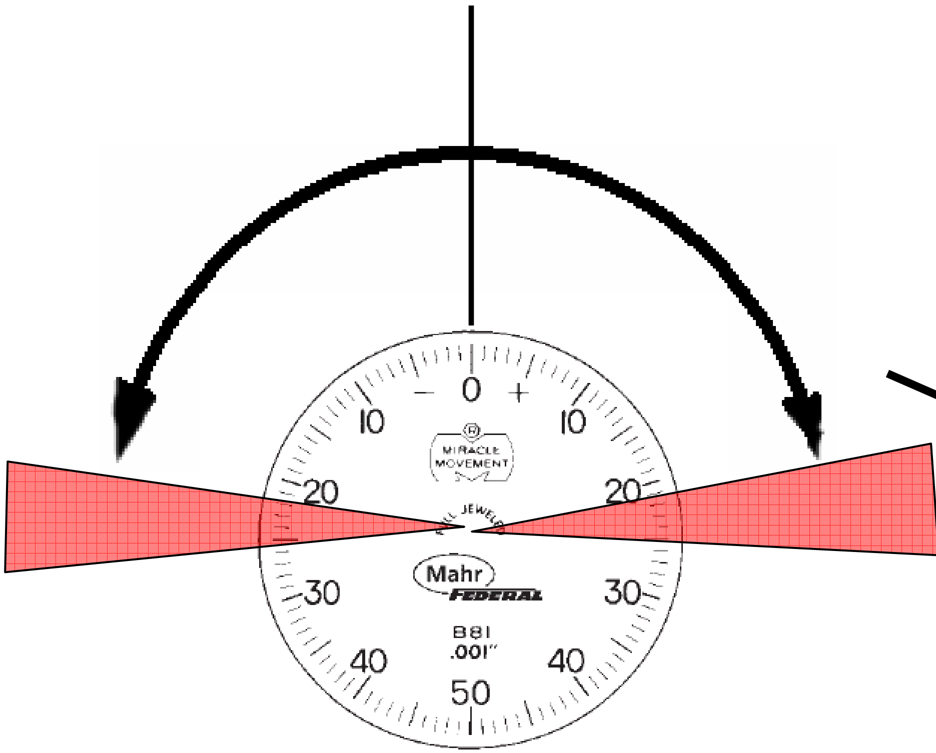
- Electronic transducer replaces meter
- Transducer has enough measuring range to handle wide range of tooling
- Let processor compensate final span

Which is the best?

- All have good and bad points
- When used in normal operating conditions and supplied by “reputable” manufacturers, good results can be obtained
- Consider
  - Ease of set up
  - Value
  - Support

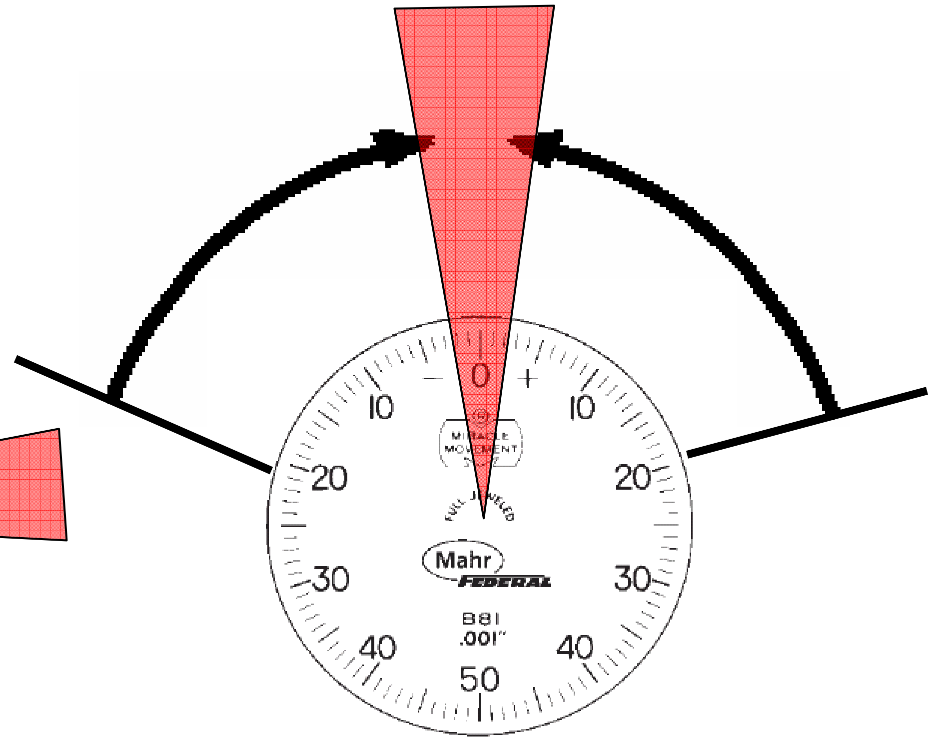
The type of air gage selected – determines where the error can be

Single Master System



Errors at extremes of tolerance

Dual Master System



Errors at center of tolerance