\[
\frac{(p_1 - p_2)}{p_1} < F_\gamma
\]

\[
Q_a = 4.
\]

\[
\frac{(p_1 - p_2)}{p_1} \geq F_\gamma
\]

\[
Q_a = 0.
\]

\[
C \cdot \left(\frac{d_o}{4.654}\right)^2 \cdot \sqrt{\frac{F_\gamma \cdot x_T}{T_a + 273.15}} \cdot \sqrt{\frac{p_1 - p_2}{p_1}} \cdot \sqrt{T_a + 273.15}
\]

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**Mahr Federal MarSolutions**

**Product Application Introduction**

**AIR FLOW GAGING**

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Mahr
Why Talk About Air Flow Gaging?

• Manufacturer’s of small holes need a way to measure them
• Mahr Federal is a known leader in air gaging, including exotic applications
• Flow is a natural element of back-pressure systems
• No air tooling required
Dimensional Air Gage Applications

• Requires two components
  – Air Tooling
  – Reflective Surface (Restriction)
    • Master
    • Part
Dimensional Air Gage Applications

What’s Happening with Flow and Pressure

Flow increases as the distance between the nozzle and restriction/gap increases.

Pressure increases as the distance between the nozzle and restriction/gap decreases.
Basic Difference in Flow Gaging

Pressure is created and increases as the distance between the nozzle/orifice and restriction decreases.

Flow increases as the opening of the nozzle/orifice increases to atmosphere (no restriction).

Air Tool

PART

Flow
Flow Gaging

What is flow gaging?

In basic terms, flow or flow rate is a measure of the amount of air/gas or liquid that flows through a particular device per some unit of time.

Units of measure are:

- liters/minute
- cm³/minute
- milliliters/second (for very low flow rates)
Air Flow Gaging - Basic Math

• Air Density Factors:
  • Temperature
  • Humidity
  • Altitude
  • Specific Gas Constant (dry air)
• Discharge Coefficient: Based on shape of orifice (~0.61 for a flat plate orifice)
Basic Flow/Back Pressure System

- Most flow gages typical for large air volume flow systems, like HVAC systems
- Less concern for dimension, more concern about controlling volume displacement and air handling
- The lower the flow rate the more unstable it is
- For measurement use, normally low input pressure used (~10psi)
Balanced Air System

• Balanced air system allows more stability for low flow rates and increase in input pressure used (~30 psi)
• Flow measures a dimensional maximum value only. It cannot explore the surface or geometry.
• Flow requires some form of un-interrupted hole(s)
• For Flow, part replaces the air tool
• Higher operating pressure allows for increased flow resulting in faster response
Air Flow Gaging – Application Elements

- Commonly qualified using 2 points, Pass/Fail only (min/max master)
- Fixed input pressure/flow rate allows ability to convert to dimensional value
- The lower the flow rate the slower the reading response
- Finding defects/clogs in multiport components is possible (surface area A)
- Magnification/Gain set to masters used
- The larger the range of hole sizes to measure the more masters needed
Types of Components
Measurable by use of Flow

- Valves
- Needles
- Nozzles (Injection Molding, Compressor, etc.)
- Multiport Miniature Parts
- Simple Fixed Restrictors
- Custom Small Hole Parts
Types of Flow Components

Valves

- Valve
  The opening where the product comes out. A wide variety of valves control how much of the product comes out, how fast, and in what direction.

- Actuator
  The spray button which enables a user to activate the aerosol delivery system. Actuators are designed to be easy to use and to control the application of the product.

- Valve Cup
  Metal cup at top of the container with sealing materials attached that holds all the valve components together.

- Stem
  The connection between the actuator and the spring.

- Stem Gasket
  The key to an aerosol can. The gasket seals the opening around the valve stem, keeping the can airtight.

- Spring
  Maintains pressure on the gasket which seals the can. Pressing down on the actuator releases that pressure, opening the seal.

- Housing
  The cylinder which holds the spring and connects the dip tube to the valve assembly.

- Dip Tube
  A hollow tube which extends from the valve to the bottom of the can, allowing the product under pressure to be pushed out through the valve.
Types of Flow Components

- Valves
- Needles

![Diagram of a needle with parts labeled: Plunger, Barrel, Tip, Hub, Needle]
Types of Flow Components

→ Valves
→ Needles
→ Nozzles (Injection Molding, Compressor, etc.)
Types of Flow Components

→ Valves
→ Needles
→ Nozzles (Injection Molding, Compressor, etc.)
→ Multiport and Miniature Parts
Types of Flow Components

- Valves
- Needles
- Nozzles (Injection Molding, Compressor, etc.)
- Multiport Miniature Parts
- Simple Fixed Restrictors
Types of Flow Components

- Valves
- Needles
- Nozzles (Injection Molding, Compressor, etc.)
- Multiport Miniature Parts
- Simple Fixed Restrictors
- **Custom Small Hole Parts**
Air Flow Measuring Systems

- **STANDARD CATALOG AIR GAGE**
  - Column or bench amp with min/max mastering
  - Some orifice sizes fit into standard product measuring range
  - Other orifices require minor gage modification

- **PC BASED AIR GAGE**
  - Uses air electronic modules direct to pc
  - Configurable with multiple modules
  - Ability to correct linearity over long ranges
Air Flow Gaging – Case Study 1

• Column/Bench Air Gage
  • Must match flow to the back-pressure type system
  • Custom master restrictor and bleed combination may be needed
  • Requires min and max masters
  • The smaller the orifice size measured the shorter the span of the masters is needed
  • Minimize air hose lengths as much as possible
  • Limited to measurement of one orifice size*
Air Flow Gaging – Case Study II

• **Air PC Gage System**
  • Able to measure multiple orifice sizes
  • Ability to correct linearity and maintain accurate readings throughout range
  • Requires 3 master set minimum for each air module used (calibration)
  • Each module uses its own regulated circuit
Air Flow Gage System

• Full PC Benchtop Gage System
  • Integral Windows based touchscreen computer
  • Air-to-electronic modules with usb connection
  • Control solenoids interfaced via IO module and power supply
  • External fixture designed specific to part
Air Flow Gaging Application

System Specification:

- Part orifice sizes can range from 0.004in./0.1mm to 0.040in./1.0mm diameter

- Part tolerance spans from 0.003in./0.08mm to 0.027in./0.69mm

- The system is designed to measure maximum diameter of a small thru-hole orifice.

- The flow rate (lpm) is calculated based on the fixed balance system and measured diameter size.
Flow Gage Technical Setup

• QA/Engineering maintenance of remote part file

<table>
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<th>PART#</th>
<th>NOM.</th>
<th>-TOL</th>
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</tbody>
</table>

• Periodic calibration check with masters (master gage when needed)

• Technician setup of machine#, mold#, and part# to be run in production (operator need only enter machine#)
Gage Operation

- Operator Selects a part to measure and is prompted to enter a machine number or any needed user information.

Valve Flowmeter System

- ACTUATOR
- SPRING CUP
- STEM
Gage Operation

- Gage retrieves all part information from remote file and enters data collection mode
Gage Operation

- No Mastering required by the operator
- Part placed firmly in gage fixture and data is collected (manual or automatic)
- Timers control gage idle time and allowed lot measurement time
- No external sensor needed
- At lot completion, exit back to main screen
Air Flow Gage Principle

- Orifice diameter sizes from 0.004 to 0.039 inch in 0.001±0.0001 inch increments (36 masters)
- Targeted accuracy 0.0001 inch and Repeat 0.00004 inch
- Only 3 Masters needed for gage operation / checks
- Each valve component has hundreds of part numbers
- Automatic data collection without a part present sensor
- Built-in auto-scaling between multiple modules
Air Flow Gaging

- “The” system to measure small hole sizes
Air Flow Gaging

What is important to remember about Air Flow Gaging?

- Simple 2-point measurement (pass/fail)
- Flow is non-dimensional – meaning it can measure max size only, not geometry or shape
- Air Gaging offers an easy solution – don’t over think it