Why "Actuator Speed" is not "Speed of Response"

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Two common questions asked by engineers with regard to venturi valves for laboratory applications are "what is the speed of response?" and "what is the actuator speed?," with many considering these the same question. However, speed of response and actuator speed are in fact completely different characteristics of venturi valves and should not be confused.

The turndown ratio of an airflow control valve is the ratio of the maximum to the minimum flow that the valve can accurately control. Typical venturi valves have a significantly higher turndown ratio than comparably sized terminal units due to the method with which each device controls airflow. With such high turndown ratios, venturi valves rarely use their full stroke in most applications, particularly when used with fume hoods.

VAV fume hoods and similar exhaust devices require airflow control valves with high-speed response in order to maintain consistent face velocity and support containment when the sash is raised or lowered. It is important to note, however, that "speed of response" is NOT the same as "actuator speed."

- Actuator speed is the time it takes for an actuator to rotate (or extend/retract for linear actuators) from its minimum to its maximum position (or vice versa).
- **ASHRAE 110-1995** "Rate [speed] of response" is defined as: "The interval required for a variable-air-volume hood to respond to a rapid opening of the sash."
- **ASHRAE 110-1995** "VAV Response Test" defines the appropriate sash movement velocity range for "speed of response" tests: "The sash shall be fully opened in a smooth motion at a velocity between 1.0 ft/s and 1.5 ft/s."
- **ANSI Z9.5-2003** defines an acceptable speed of response, or response time: **"A response time of <3 sec. after the completion of the sash movement** is considered acceptable for most operations. Faster response times may improve hood containment following the sash movement."

Speed of response is always less than actuator speed in practical application. The full turndown ratio (and actuator stroke) of a venturi valve will never be realized in a fume hood application for two reasons:

1. To ensure the venturi valve is capable of exhausting sufficient CFM with the sash completely open, the valve will typically be sized to handle slightly more volume than this maximum requirement (safety factor).
2. ANSI Z9.5-2003 states that "the mechanism that … regulates the hood exhaust volume (i.e. venturi valve) shall be designed to ensure a minimum exhaust volume … equal to the larger of 50 cfm/ft of hood width, or 25 cfm/ft^2 of hood work surface area". Therefore, a 4 ft hood will have a minimum exhaust rate of 200 cfm, a 6 ft hood 300 cfm, etc. Because the relationship between actuator position and airflow through a venturi valve is non-linear with the curve steepening as the venturi valve approaches it full open position (maximum flow), eliminating the lower flow range of the valve will eliminate a disproportionately larger portion of the required actuator stroke.

Example:

Assumptions:

Fume hood width = 6 ft

Target fume hood face velocity = 100 fpm

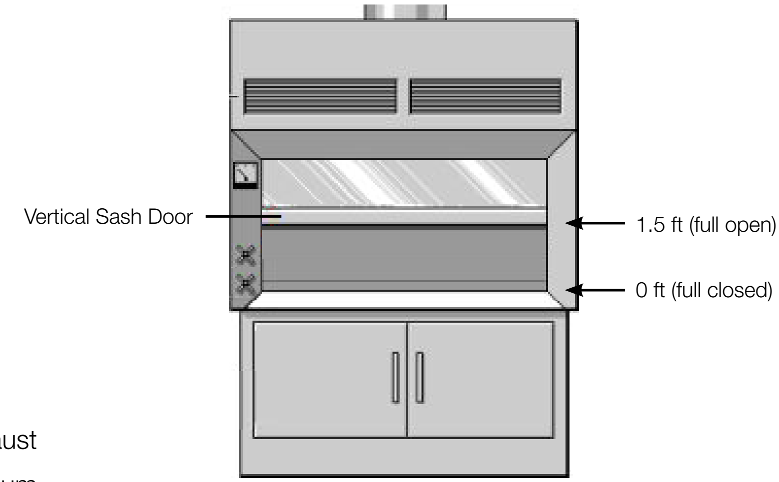
Minimum sash position = 0 ft

Maximum sash position = 1.5 ft

Velocity of sash movement = 1.5 ft/s

Venturi valve flow range = 60 to 1000 cfm (Size 10)

Actuator speed = 4 seconds (full stroke, 90 degrees)



Based on ANSI Z9.5-2003 requirements, the minimum exhaust rate through this hood would be 300 cfm and the maximum exhaust rate can be calculated based on our assumed face velocity and maximum hood opening **(figure 1)**.

Maximum Exhaust Rate = (100 fpm)x(1.5 ft)x(6 ft)= 900 cfm

Note that only 36% of the total actuator stroke is used for this particular application.

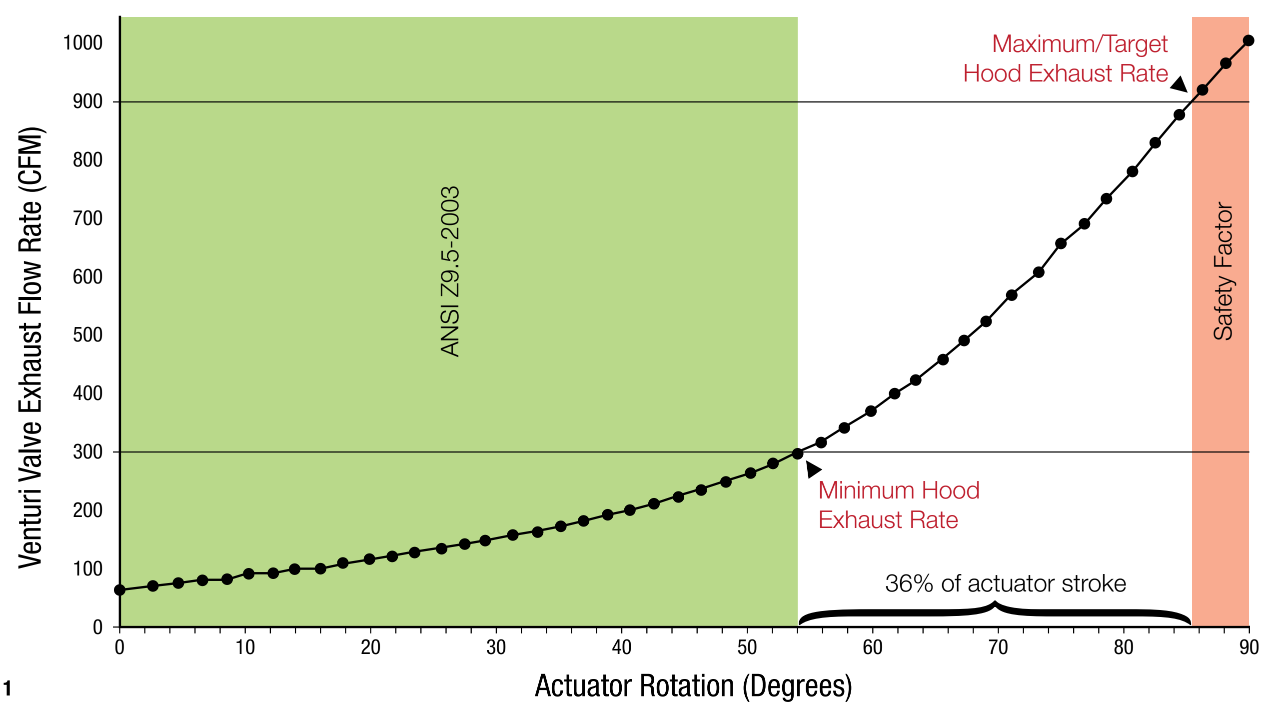


FIGURE 1

Furthermore, if the fume hood controller is programmed correctly, the actuator will begin opening/closing the venturi valve immediately after sash movement is initiated. We have conservatively assumed that the sash would be raised at 1.5 ft/s (high end of velocity specified by ASHRAE 110-1995 for the VAV Response Test), resulting in the actuator moving towards its final position for approximately one second before the sash reaches its maximum position of 1.5 ft. Since the actuator speed in this example is 4 seconds (i.e. time for actuator to rotate from 0 to 90 degrees), we can calculate the approximate position of the actuator after sash movement (in one second the actuator will rotate approximately 22.5 degrees) **(figure 2)**. The time required, **after sash movement**, for the face velocity (i.e. exhaust flow rate) to reach and maintain within 10% of the design value (100 fpm in this example) is the speed of response for the venturi valve.

Further analysis of this chart indicates that only 11% of the full actuator stroke remains to reach our required maximum flow rate of 900 cfm. Using the actuator speed and remaining stroke percentage, we can calculate the approximate speed of response for the venturi valve in this example.

(4 seconds)x(11%)= 0.44 second response time

The key take-away from this example is that although the "actuator speed" was 4 seconds, the "speed of response" was well under 1 second. Actuator speed and speed of response are NOT the same.

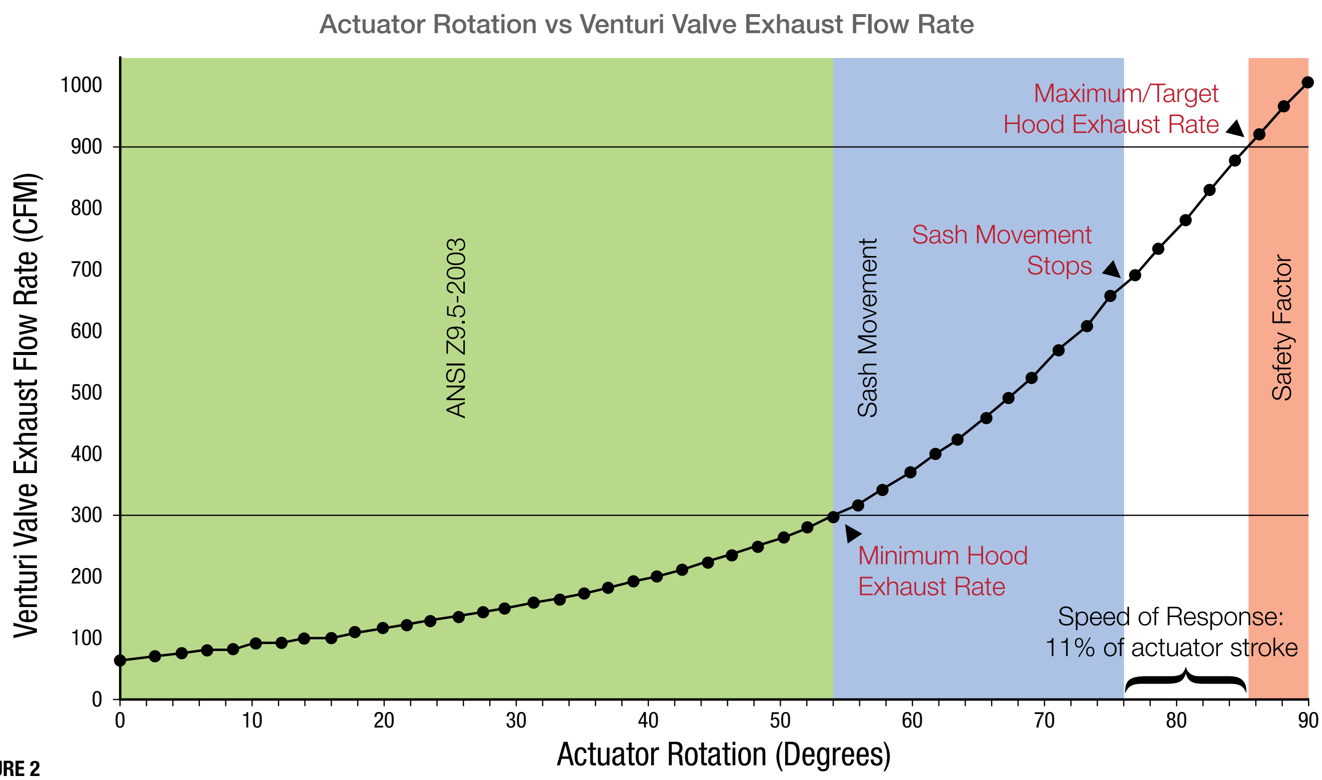


FIGURE 2

Summary

Speed of response is dependent on the following variables and should be verified whenever these variables are applied in new configurations.

- **Fume hood size**
- **Venturi valve size**
- **Fume hood controller programming**
- **Method of measuring/controlling hood face velocity (sash position sensor vs. sidewall sensor)**
- **Actuator speed**

The above example can be used for different valve and/or fume hood sizes to evaluate project-specific configurations. For more information, please contact Nolan Hosking, Critical Environments Product Manager, at **nolanh@price-hvac.com**.