PRODUCT APPLICATION GUIDE

A technical bulletin for engineers, contractors and students in the air movement and control industry.

Actuators for Commercial HVAC Dampers

To accomplish its intended purpose, every damper installed in an HVAC system must be equipped with an appropriate actuator. Selection of the appropriate actuator for a specific damper requires the consideration of a number of factors. This article will examine the actuator selection process. *(While damper actuators are often called by other names such as: damper motors, damper operators, motor-packs, etc., damper actuator is the appropriate terminology.)*

Dampers are available with a wide variety of installed actuators. Dampers are also shipped without actuators. These are normally set up for installation of an actuator in the field (*usually after the damper has been installed in the HVAC system*).

Considerations in the actuator selection process

The following factors must be considered. Each will be discussed in greater detail. They are listed here to provide a perspective of the selection process.

- Who will supply and install the actuator? Will it be factory installed by the damper manufacturer? Or will it be supplied by others for field installation?
- Will the actuator be direct-coupled to the damper's operating shaft, or will it be connected using crank arms and linkage?
- What will power the actuator? Will it be manual, electric, or pneumatic? If electric, are there any specific NEMA rating requirements for the actuator?
- What type of control action will the damper perform? Will it be two position, modulating, floating, or some other type of control?
- How much torque must the actuator deliver to positively and accurately position the damper?
- Other actuator considerations

Who will supply and install the actuator?

Theoretically, all damper manufacturers can supply any commercially available damper actuator. Greenheck catalogs and stocks a variety of frequently used damper actuators. These actuators may be ordered factory installed. Factory installed actuators can be mounted internally (on the face of the damper, exposed to the airstream) or externally. External mounting may require the damper to be furnished with a sleeve or side plate to provide a mounting location external to the ductwork and out of the airstream.

When a control specialist is employed to provide a control system for the complete building HVAC system, the control specialist may furnish appropriate damper actuators and install them in the field. In this instance, dampers are usually supplied with extended operating shafts for connection of field installed actuators.

Damper with actuator mounted internally

Ordering the appropriate actuator(s) factory installed by the damper manufacturer is usually less expensive and the best way to insure an appropriately sized and installed actuator. Greenheck can supply and

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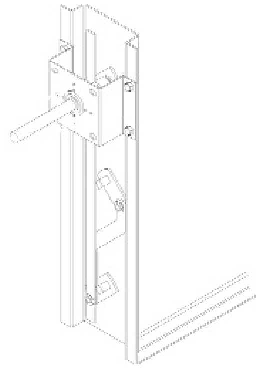
install most actuators that might otherwise be furnished (and field installed) by a control specialist.



Extended Operating Shaft

It should be noted, the latest version of UL's Fire Smoke Damper Standards require all actuators on UL Classified Smoke and Combination Fire Smoke Dampers be furnished and installed by the damper manufacturer at the time the damper is manufactured.

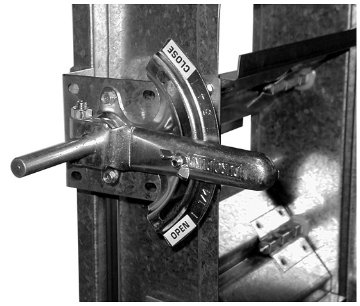
Will the actuator be direct coupled to the damper's operating shaft, or will it be connected using crank arms and linkage?

Prior to the early 1990s, most damper actuators required the use of lever arms (also called crank arms) and linkage rods to convert the rotary or linear output motion of the actuator to the 90° rotation required to operate a damper. Over the past decade, electric actuators with 90° rotary output designed to couple directly to a damper's operating shaft have become widely available. Use of these direct-couple actuators has greatly simplified the installation of an actuator on a damper by eliminating the need for arms and linkage and the often-frustrating task of adjusting such linkages. Using direct-coupled actuators also insures that rated actuator torque is applied directly to the damper's operating shaft. This simplifies matching an actuator with the required damper's torque as no allowance needs to be made for losses due to linkage arrangements.

While many electric actuators are available for direct–couple damper connection, pneumatic actuators, for the most part, are linear output devices which still require crank arms and linkages to operate a damper.

Will the actuator be electric, pneumatic, or manual?

If the damper is to be fixed in one position after initial adjustment (such as a balancing damper), or if its position needs only be changed once or twice a year (for summer/winter changeover), a manual locking quadrant actuator may be all that is required. If the damper is required to operate automatically as part of an HVAC system, an electric or pneumatic actuator should be provided.



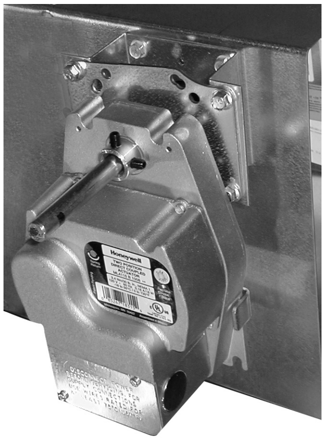
Manual Quadrant Actuator

Pneumatic actuators normally require a 20 to 25 psi instrument air supply system. An instrument air system insures the availability of clean dry air. If such a system already exists or is to be installed as part of a new HVAC system, then choosing a pneumatic damper actuator is a viable option. Without an available source of instrument air, pneumatic actuators should not be considered.

Pneumatic actuators respond to varying control air pressures and are selected with appropriate spring ranges to operate a damper. These springs oppose the force created by air pressure against the actuator's diaphragm. When the force on the diaphragm exceeds the spring force, the actuator's piston extends, causing the connected damper to open or close. Pneumatic actuators are inherently "fail-safe" as they return to their normal position when air pressure is removed. Spring ranges of 5 to 10 psi and 8 to 13 psi are normally used for pneumatic damper actuators. Pneumatic damper actuators are simple, reliable, and relatively inexpensive. However, a source of instrument air must be readily available when used.

Pneumatic Actuator

Electric actuators are widely used for all damper control applications. They are available in a variety of configurations, including popular direct-coupled models. Since electric actuators are available with supply voltages of 24 Vdc, 24, 120, and 240 Vac, it is necessary to designate the voltage when selecting the actuator. Transformers are required to obtain other voltages, such as 440 and 575 Vac. Electric actuators are not inherently "fail-safe." For "fail-safe" operation, spring return models may be specified.



External Mount
Electric Actuator

Greenheck stocks a variety of the more popular pneumatic and electric actuators. These can be factory installed on dampers before they are shipped, or furnished in kit form for field installation on dampers.

What type of control action will the damper perform in the HVAC system?

Before an appropriate actuator can be selected, the damper's function in the system must be determined.

- Will the damper be used to adjust airflow to a required design setting, and then be locked permanently in position? Such a damper would be called a balancing damper and would most likely require only a manual hand quadrant actuator.
- Will the damper be required to open fully to allow airflow and/or to close completely to shut off airflow? This is called two-position control. If operation is required only one or two times each year (such as for summer/winter changeover) a manual hand quadrant actuator may be appropriate. However, if operation is required on a regular basis, or if automatic changeover is desired, a two-position actuator should be selected.
- Will the damper be required to control temperature, pressure, or airflow by moving to any desired position between open and closed as required by a controller? This operation is called modulating or proportional control. A related but less precise type of control, floating control, is rarely used in commercial HVAC systems.
- Will the damper be required to return to its open (or closed) position in the event of a power failure or other emergency? If this is the case, a "fail-safe" actuator is required. If the actuator is electric, it will require a spring return type actuator. As mentioned previously, pneumatic actuators are inherently "fail-safe".

Terminology used by the control industry can be confusing in this area. When an actuator is installed (or linked) to return the damper to its closed position upon power interruption, it is called a "normally closed" installation. An actuator installed (or linked) to open the damper on power interruption is called "normally open". These terms bear no relationship to the normal position of the damper during HVAC system operation. Unless all parties are familiar with the control industry meaning of the terms "normally open" and "normally closed" it is suggested that the terms "fail closed" and "fail open" be used to prevent misunderstanding.

If the damper's function is only to open or close, a two-position actuator is required. This is accomplished with a pneumatic actuator by applying full air pressure (20 to 25 psi) or no air pressure to the actuator. Pneumatic actuators can be linked to open or close the damper at full air pressure and vice versa at no air pressure. Therefore it is necessary to specify fail-open or fail-close when ordering a pneumatic actuator installed on a damper.

Two-position electric actuators are available in two general configurations. The most simple is the two-wire spring return actuator. This actuator is controlled by switching electric power on or off. Power "on" runs the actuator to its "on" position. Power "off" allows the actuator's spring to return the actuator to its "off", "normal" or "fail" position. Other configurations of two-position electric actuators require three or more wires and a three-wire (SPDT) switching controller. These actuators are available in both spring return and non-spring return configurations.

Actuators required to accomplish modulating control (positioning the damper to any position between open and closed) must receive a modulating control signal from some device (or controller) that monitors temperature, pressure, or some other condition in the HVAC system. The damper actuator selected must be compatible with the control signal generated by the controller. Most electric controllers used in commercial HVAC control systems generate a 2 to 10 Volt dc control signal (sometimes described as a 0 to 10 Vdc control signal). Other controllers may put out a 4 to 20 milliamp dc signal. Fortunately the 4 to 20 milliamp signals can (by the use of a resistor) be converted to a 2-10 Vdc signal. It is necessary to specify if the high or low end of the control signal range should open (or close) the damper. However, most of these actuators can be changed to drive the damper open or closed by a switch (on the actuator).

An older, but still commonly used modulating control system uses controllers equipped with 135-ohm slide-wires or rheostats. Honeywell Series 90 controls are based on this system. If this type of controller is being installed, the damper actuator must be compatible. Unfortunately, actuators that handle 2–10 Vdc control signals will not function if the controller is the 135-ohm type (and vice versa).

Direct Digital Control or DDC as it is commonly known, uses digital technology to monitor conditions and signal changes required in an HVAC system. DDC controllers generally have provisions for an analog output (also called "AO"), usually a choice of either 2-10 Vdc or 4-20 milliamp dc. Due to this feature, most DDC controllers can directly operate modulating electric damper actuators. Two-position actuators may require an interface device or relay that can function in response to the DDC controller's digital output (or "DO") as few two-position actuators are set up to respond directly to a DDC's digital output. Pneumatic actuators will always require transducers to transform the DDC control signal into the appropriate changes in pneumatic air pressure.

How much torque must the actuator deliver to positively and accurately position the damper?

Damper actuator torque is rated in inch pounds (in-lb). A damper's torque requirement is usually expressed in inch pounds per square foot (in-lb/ft^2). The actual torque required to operate a damper is affected by a number of factors, some of which are under the damper manufacturers control, but some are not. For example:

- Opposed blade dampers require slightly less torque than parallel blade dampers
- Low leakage dampers (with blade and jamb seals) require more torque than dampers without low leakage seals
- HVAC system pressure and airflow velocities also have a bearing on a damper's torque requirements.

A design and construction feature inherent to Greenheck's commercial HVAC control dampers that makes it difficult (but not impossible) to twist or rack a Greenheck control damper during installation is Greenheck's reinforced frame corners. Standard bearings and extruded bearing raceways on Greenheck's dampers also minimize torque requirements. How the damper is installed in the ductwork and how the actuator is installed can have a significant affect on torque requirements. Dampers installed twisted or out-of-square may require many times more torque than dampers installed square and plumb.

Always select a damper actuator with a rated torque that is greater than the damper's required torque. *(Use the chart on page 5 to determine the required torque.)* When selecting an actuator that will use crank arms and linkage rather than the preferred direct-couple connection, an additional safety factor of 30 to 50% is recommended. When in doubt, the next larger size actuator is always the safest choice.

The following is offered to assist you in the selection of a damper actuator with the appropriate torque.

First determine what type of damper is involved opposed blade or parallel blade, with or without low leakage seals. Then determine the HVAC system characteristics as shown in the torque requirements table. Determine the area (sq. ft.) of the damper and apply the appropriate torque requirement from the table.

Example:

- A 36 inch x 20 inch opposed blade damper with low leakage seals in an HVAC system with maximum system pressures of 2.5 in. wg and maximum design airflow velocities of 2000 fpm.
- Damper area is 36 inch x 20 inch/ 144 inch = 5 square ft.

This opposed blade damper with low leakage seals requires 7.5 in-lb/ft^2 in an HVAC system with 2.5 in. wg and 2000 fpm. The torque required is 7.5 x 5 = 37.5 in-lb.

Other actuator considerations

Electric damper actuators are available with a variety of options that do not necessarily relate to their ability to appropriately operate the damper. Normally, electric damper actuators have a NEMA 1 enclosure. This is intended for general-purpose indoor operation. Specifications may require enclosures rated for weatherproof or explosion-proof (NEMA 4 or NEMA 7) environments. Not all actuators can be provided with these enclosures and when required the cost is significantly more.

Electric actuators are available with a variety of accessories that may assist in the HVAC system operation. A typical accessory is the auxiliary switch. Auxiliary switches are used to turn equipment on (or off) when the damper reaches a desired position. An example of this would be to keep a fan from starting before a damper has opened far enough to permit airflow. Auxiliary switches are often fixed to operate at the end of the actuator’s stroke. Some actuators, however, offer switches that are adjustable to operate at any point during actuator travel.

Summary

The actuator selection process is not a simple one. Often the information necessary to select the appropriate actuator is not available. Unfortunately, this can result in improper actuators being furnished causing confusion and extra cost.

Furnishing two-position damper actuators, factory installed is straightforward and causes few problems. Care should be taken, however, to carefully coordinate requirements when ordering modulating actuators for factory installation.

Factory installed damper actuators should always be considered when time is available and overall costs are a consideration. The benefits of a factory installed damper actuator often outweighs the time required to coordinate these actuator requirements in the field.

Torque Requirements

	Opposed Blade Dampers with		Parallel Blade Dampers with	
	No Seals	Low Leakage Seals	No Seals	Low Leakage Seals
Maximum Pressures of 2 in. wg or Maximum Velocities of 1500 fpm	3 in-lb/ft^2	5 in-lb/ft^2	4 in-lb/ft^2	7 in-lb/ft^2
Maximum Pressures of 3 in. wg or Maximum Velocities of 2500 fpm	4.5 in-lb/ft^2	7.5 in-lb/ft^2	6 in-lb/ft^2	10.5 in-lb/ft^2
Maximum Pressures of 4 in. wg or Maximum Velocities of 3000 fpm	6 in-lb/ft^2	10 in-lb/ft^2	8 in-lb/ft^2	14 in-lb/ft^2

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