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Industry insight

Energy cost savings using an effective door closer

Abstract

Door closers are commonly used in commercial buildings, not only to ensure doors are closed and securely latched, but also to reduce the airflow through door openings. However, as the air pushes into or out of a building- moving from an area of high pressure to one of lower pressure - it exerts incredible amounts of force on the doors and can prevent door closers from functioning properly. These significant pressure differentials often occur along the exterior of a building, as well as between adjoining rooms or wings of a facility. The result of the pressure differential is that the moving air "holds" the door open, preventing the door from securing properly.

The most common solution is to increase the closer's spring size. This provides the door with enough force to close and latch, but also increases the amount of force necessary to open the door. This can potentially cause the facility to be in violation of the Americans with Disabilities Act or ADA, which requires that doors be operable with just 5 pounds of force or less.

This study assessed the potential heating and cooling energy cost saving from using an effective door closer in the cities of Minneapolis, Boston, San Francisco, and Phoenix. It was found that, under a greater indoor–outdoor pressure differential, using an effective door closer would significantly decrease energy costs. This paper focuses on energy savings from using an effective closer and does not address the inherent security and life safety risks from doors not closing and latching properly.

Introduction

Because the building sector accounts for nearly 41% of the total primary energy consumption in the United States[1], energy saving in buildings has the potential to significantly reduce overall energy consumption. Preventing air infiltration through the building envelope is considered to be among the most important factors in building energy saving [2–4]. The National Institute of Standards and Technology (NIST) has reported that annual heating and cooling energy costs could be reduced by 3–36% for different climate zones if the target air tightness level were achieved [5]. Therefore, building designers are paying more and more attention to the reduction of airflow through exterior door openings.

Door closers are widely used to address this issue in commercial buildings. They also improve ease of use and accessibility, which are significant concerns for building designers and facilities management. In order to ensure accessibility for all users, the maximum force required to open a door is defined by the ADA standard. These requirements, in turn, limit the amount of force that can be applied by a door closer to close the door. When the indoor–outdoor pressure differential created by a ventilation system is relatively large, the door closer with low opening force set to comply with these requirements may not be able to overcome the resistance and fully close and latch the door, allowing it to remain open. The continuous airflow through this door opening could significantly increase the heating and cooling energy costs.

Facilities managers have few options for addressing this problem. The least expensive solution - increasing the closer's spring size - is likely to restrict accessibility and violate the ADA's opening force requirements. Installing an auto operator on every exterior door would solve the problem, but they are considerably higher cost, and require line power and a trained electrician to install.

The only other option for addressing the source of the problem has been to hire an independent HVAC contractor who specialized in test and balance work. They will evaluate the system and determine what quantities of air are being delivered, and then balance the system to ensure that each air vent is actually delivering the quantity of air that was specified by the HVAC engineer who designed the system. For most building owners, this option is considered to be a last resort as the test and balance process is complex, time consuming and, depending on the size of the building, can cost several thousand dollars. If the tests reveal bigger problems with the installation, design or the unit itself, the contractor will be unable to balance the system. Even if the system is able to be balanced properly, it can be thrown back out of balance by dirty filters, reconfiguring registers or office remodeling.

The best solution is to install a door closer that is both effective and affordable. An effective door closer will do more than simply close the door; it will control the door in both the opening and closing cycles to ensure compliance with ADA while at the same time preventing damage and injury caused by abuse, wind, building pressure or other factors. As this study shows, the potential cost savings of installing such a closer can exceed $1000 per door, particularly in regions with extreme variations between the indoor and outdoor temperature.

Methods

As discussed above, an ineffective door closer or closer with low opening force to accommodate ease of use may not be able to overcome the force on the door due to the pressure differential across the door. In this case, a door may be held open, resulting in a significant increase in heating and cooling energy costs.

This study assessed the heating and cooling energy cost saving from using an effective door closer in four cities in different climate zones: Minneapolis, Boston, San Francisco, and Phoenix. Minneapolis is in climate zone 6, which represents a very cold climate; Boston is in climate zone 5, which represents a cold climate; San Francisco is in climate zone 3, which represents a mild climate; and Phoenix is in climate zone 2, which represents a hot climate.

The dimensions of the door were set at 7 feet (2.1m) in height and 3 feet (0.9m) in width, which were the average values from our field measurements of 15 doors. The ratio of door area to wall area was set at 0.12. The measurements showed that the indoor–outdoor pressure differential when the door was fully closed, P(0), ranged from 3 to 26 Pa, with a median value of 12 Pa. Note that the measured indoor–outdoor pressure differentials have accounted for the impact of both the ventilation system and wind pressure.

The closer can be adjusted by turning a screw that preloads the springs inside the closer. The closer size designation (0, 1, 2, and 3) represents an adjustment of the closer in which this screw was fully rotated 0, 3, 6, and 9 times, respectively, from the lower stop. Four spring settings, closer size 0, closer size 1, closer size 2, and closer size 3 were tested in order to measure the closing torque produced by a door closer under a certain spring setting. Fig. 1 below shows the measured closing torque as a function of door opening angle under different spring settings. Note that, according to the ADA standard for accessibility, less than 5 lbs. (22 N) of force should be required to open the door [6]. At the spring setting of closer size 1, the force required to open the door to 70° would typically be slightly less than 22 N. By contrast, the closer size 2 and closer size 3 settings will not meet the ADA standard and may not be desirable for ease of use and accessibility.

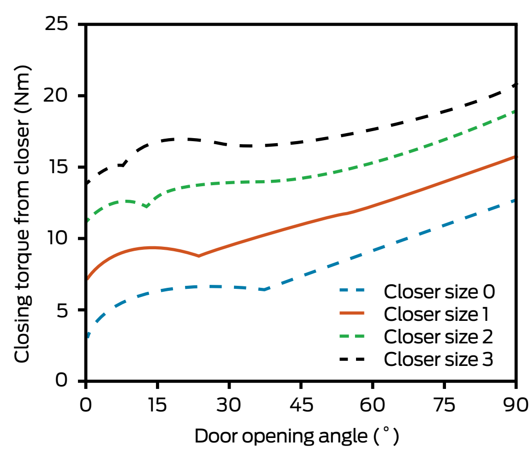

Fig. 1. Measured closing torque as a function of door opening angle under different spring settings.

Case studies

This study applied the proposed method for assessing the heating and cooling energy cost saving from using an effective door closer to four cities in different climate zones: Minneapolis, Boston, San Francisco and Phoenix. An effective door closer is one that will always ensure the door is closed and secured in the face of HVAC pressure. An ineffective closer will not have enough closing force to ensure the door is closed and secured in the presence of HVAC pressure. The resulting effects of an ineffective door closer is that the door remains slightly open allowing conditioned air out of the building.

Minneapolis

Minneapolis is in climate zone 6, making it the coldest region studied in this paper. Because this region has the largest temperature differential, it is subject to greater indoor–outdoor pressure differentials, resulting in greater airflow through the door opening when using an ineffective door closer. With a larger temperature differential, more energy is needed to condition the additional air flowing through the door opening. As a result, the energy cost savings are higher in Minneapolis than any of the other cities studied. It is estimated that using an effective door closer in this region would save building owners $1695 annually per door.

Boston

Boston is in climate zone 5, and its temperature differential is slightly less than that of Minneapolis. However, by using an effective door closer in this region, it is estimated that building owners would save $1478 annually per door.

San Francisco

San Francisco is in climate zone 3, and was used to represent regions with a milder climate than Boston or Minneapolis. As a result of having the smallest temperature differential, San Francisco also showed the smallest amount of savings potential as significantly less energy was needed to condition the additional air flowing through the door opening. However, the savings were still significant, at an estimated $879 annually per door.

Phoenix

Located in climate zone 2, Phoenix represents the hotter regions. Although heating costs are significantly less in winter than Boston or Minneapolis, the cooling costs in summer are substantial. By installing an effective closer, building owners in this region are estimated to save $1140 annually per door.

Results

Figure 2 shows the calculated annual energy cost saving from using an effective door closer with the correct spring and valve adjustments under different pressure differentials in Minneapolis, Boston, San Francisco, and Phoenix when the door closer spring setting is closer size 1. Note that at the closer size 1 setting, it can normally be assumed that the force required to open the door to 70 ° is slightly less than 22 N. Therefore, it is worthwhile to explore the energy cost saving from using an effective closer at this spring setting.

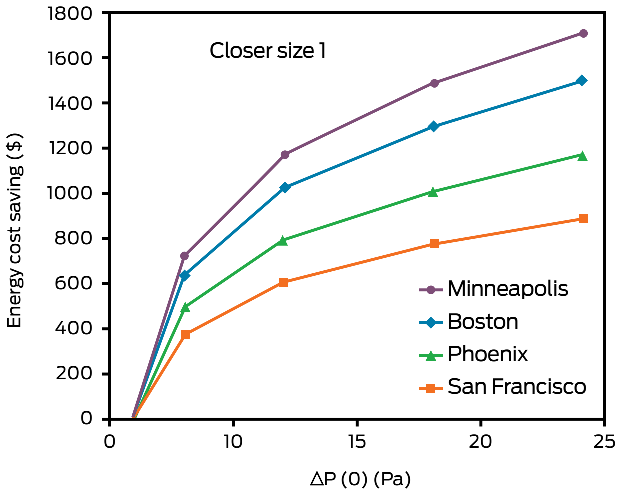

Fig. 2. Calculated annual heating and cooling energy cost saving from using an effective door closer under different pressure differentials in Minneapolis, Boston, San Francisco, and Phoenix when the door closer spring setting is closer size 1.

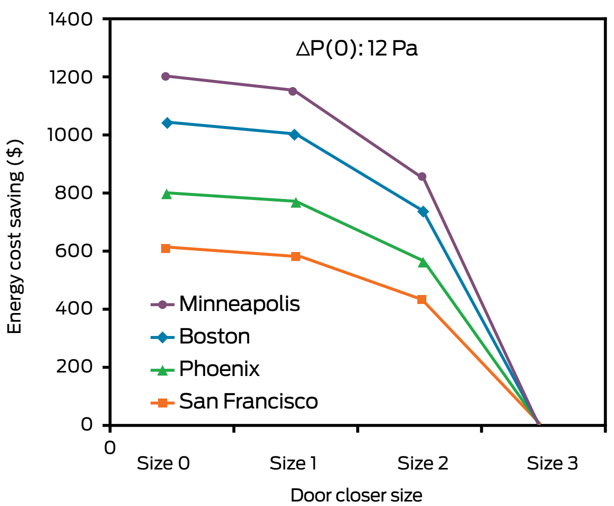

Fig. 3. Calculated annual heating and cooling energy cost saving from using an effective door closer at different spring settings in Minneapolis, Boston, San Francisco, and Phoenix when ΔP(0) is 12Pa.

Figure 3 shows the calculated annual energy cost saving from using an effective door closer under different door closer sizes. Note that at the setting of closer size 3, the door closer can fully close the door under this pressure differential. The larger closer size corresponds to a greater amount of closing torque produced by the door closer. Thus, when using a closer with a larger size, the lost energy cost would decrease because of the reduced airflow through the door opening. However, a larger closer size will increase the force required to open the door, reducing ease of use and potentially creating an ADA violation.

Conclusions

This study examined the heating and cooling energy cost saving from using an effective door closer. Within the scope of this study, the following conclusions can be made:

(1) As the pressure differential increases from 6 to 24 Pa, the calculated annual heating and cooling energy cost saving for office buildings in Minneapolis, Boston, Phoenix, and San Francisco would increase from $0 to $1695, $1478, $1140, and $879 per door, respectively.

(2) The cost saving from using an effective door closer in San Francisco (mild climate) would be lower than that in Minneapolis (very cold climate), Boston (cold climate), and Phoenix (hot climate).

(3) When using a closer with a larger size, the energy cost lost would decrease because of the reduced airflow through the door opening, but the large closing torques when the spring setting is more than closer size 1 may reduce ease of use and accessibility and violate the ADA standard.

Currently, there is a tradeoff between energy cost saving and the accessibility of the door. One of the most effective ways to deal with this issue is to ensure that the door closers within a facility are functioning properly. Proper techniques for making these adjustments are outlined in Appendix A. If the existing closer cannot be adjusted sufficiently to allow the door to overcome the force of the building pressure, a more effective closer should be installed. When choosing a replacement, consult with an architectural openings hardware specialist to find an appropriate solution that will not simply close the door, but will also ensure ADA compliance while controlling the door in both the opening and closing cycles to prevent damage and injury caused by abuse, wind, building pressure or other factors.

Appendix A

Before making any adjustments to a door closer, always check for misalignment, sagging, or other conditions that could prevent free movement of the door. These issues will need to be corrected before any adjustments are made. Then check to see if there is oil on the cover or closer body; if there is, replace the closer.

Next, remove the closer cover to view three adjustment/ regulating screws and the spring adjustment; any closer with a "delay" feature will have an additional valve. The closer's back check valve cushions the opening swing to slow the door down and prevent it from slamming into the stop. Turning the valve clockwise will give you a stiffer back check, while turning the valve counter clockwise will give you a lighter backcheck. For more abusive applications, an overhead stop can be used.

The main speed valve controls the main closing speed of the door and is the area from the door in the wide open position down to the last 10˚-15˚, or so, before the latch. Turning the valve clockwise will make the door close more slowly, while turning the valve counterclockwise will cause the door to close faster.

The latch speed valve controls the latch speed of the door, which is approximately the last 15˚ of closing. Turning the valve clockwise will cause the door to latch more slowly and gently. Turning the valve counterclockwise will cause the door to latch faster, and more abruptly.

The spring adjustment is located on the end of the spring tube and is used to adjust the spring strength or the amount of force needed to close the door. Turning the screw clockwise will give the closer more closing power, but it's important to note that this will also makes the door more difficult to open. Turning the screw counterclockwise, will give the door less closing strength. This makes the door easier to open, but can also prevent the door from closing with enough force to latch securely.

The regulation valves are designed to adjust the flow the hydraulic fluid in the closer which regulates the door closing speed through various phases of the closing cycle. These valves have limited adjustment and if opened up too far can cause damage to the seals and create hydraulic fluid leaks. Note that although the regulation valve assemblies are staked to provide some warning when the screws are at max adjustment, they cannot prevent the valve from being over adjusted.

The most common reason why users over adjust the regulation valve is to create more force to ensure the door latches during closing. However, while opening up or adjusting the latch speed will increase the latch speed, it does not increase the closing force provided for latching the door. If more force is needed to latch the door, the spring power should be increased.

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