BUILD SIMUL (2012) 5: 345 – 350
DOI 10.1007/s12273-012-0091-6

# The impact of air filter pressure drop on the performance of typical air-conditioning systems

**Nabil Nassif (✉)**

*Department of CAAE Engineering, North Carolina A&T State University, 455 McNair Hall, 1601E. Market Street, Greensboro, NC 27411, USA*

## Abstract

Filters are used in heating, ventilation, and air-conditioning (HVAC) systems for both commercial and residential buildings to protect the equipment and improve indoor air quality in conditioned spaces. Although there are many benefits of using the air filter in an air-conditioning system, the resistance associated with it can increase fan energy use and may adversely affect air-conditioning system performance and efficiency. The paper explores the impact of air filtration on energy consumption for a typical air-conditioning (AC) system with constant- or variable-speed fan. A whole building simulation model is used to simulate the annual energy consumption for various air-conditioning system capacities, different levels of filter cleanliness, and various filter minimum efficiency reporting values (MERV). The results indicate that with a constant-speed fan, the cooling energy use increases as the filter gets dirty over time and the energy use in the fan may increase but this depends heavily on the investigated fan performance curve. With a variable-speed fan, the fan energy use increases with a dirty filter but the cooling and heating energy uses are slightly affected. The fan energy use rise due to the dirty filter depends mainly on air system capacities, filter MERV ratings, and the degree of the filter cleanliness.

## Keywords

air filters,
HVAC system,
MERV,
energy consumptions,
fans

## Article History

Received: 3 April 2012
Revised: 2 June 2012
Accepted: 19 June 2012

© Tsinghua University Press and Springer-Verlag Berlin Heidelberg 2012

## 1 Introduction

Filters are typically used in both commercial and residential building systems. They are located in the main airstream to protect the equipment and improve indoor air quality in conditioned spaces (ASHRAE 2008). Without filters, particles may accumulate on fans and heat exchanger coils adversely affecting heat transfer (Yang et al. 2007a, b; Siegel and Nazaroff 2003). Although there are many benefits of using the air filter in an air-conditioning system, the resistance associated with it can add extra energy power in the fan operation and may affect adversely on air-conditioning system performance (Nassif 2012; Stephens et al. 2009). As the filter gets dirty over time, the pressure drop across it raises and causes not only an increase in fan power but a reduction of air-conditioning system performance and air distribution system efficiency. With a typical constant-speed fan motor, as filter gets dirty the static pressure increases and airflow rate drops. The reduced airflow rate leads to reduce the system capacity and sensible heat ratio (James et al. 1997; Palani et al. 1992; Parker et al. 1997). With variable-speed fan, as the resistance increases due to a dirty filter, the fan speed increases, and thereby the fan power, in order to maintain the same airflow rate and meet space sensible load requirements. Thus, the study will investigate these effects on whole system performance that includes fan and air-conditioning system. The impacts of air filters on energy consumption for typical air-conditioning (AC) systems equipped with constant- or variable-speed fan are investigated. The study considers a small commercial building (small retail) with various system capacities and locations.

## 2 Methodology

ANSI/ASHRAE Standard 52.2-2007 (ANSI/ASHRAE 2007) uses the minimum efficiency reporting value (MERV) to rate the effectiveness of air filters. The scale is designed to represent the worst case performance of a filter when dealing with particles in the range of 0.3 to 10 micrometers ($1.18 \times 10^{-5}$ to $39.3 \times 10^{-5}$ inches). The MERV rating is from 1 to 16. Higher MERV ratings correspond to a greater percentage of particles captured on each pass, with a MERV 16 filter

E-mail: nnassif@ncat.edu