Issue 133
June 2023
Division of Technical Resources
Office of Research Facilities
National Institutes of Health
Technical News BULLETIN

Fan Arrays in Air Handling Systems

Introduction

Fan array (or "fan wall") systems within air handling units (AHUs) provide airflow and static pressure via a bank of fans grouped in an array, with each fan directly connected to its motor shaft. Unlike traditional centrifugal single-fan applications that house a scroll to discharge into a separate plenum or directly into the ductwork, direct-drive fan arrays pressurize the plenum that houses them. Fan arrays at NIH typically accommodate no more than eight fans, as there is a diminishing return in terms of cost, redundancy, and maintenance beyond that number.

Manufacturers, designers, and end users apply these characteristics to reduce the length of AHUs, increase redundancy, and, as the use of multiple small fans reduces the need to shut down the entire fan system, make replacing fans and motors easier.

General Array Selection Criteria

The system designer shall select fan arrays for parallel airflow where all fans in the array have identical motors, fan speeds, and system performance curves. As with housed belt-driven fans, performance curves for fan arrays shall show volumetric flowrate of a fan as a function of total pressure, brake horsepower, and fan efficiency and should define regions of system instability. Performance data for fan arrays should define the data for individual fans in the array and each additional fan operating in parallel. Where arrays are designed to provide N+1 fan redundancy, designers must verify that fan systems in the N operating condition perform within a stable region so as to avoid uneven airflow and pressure, increased noise, and mechanical damage.

Designers shall also select isolation dampers for each fan in the array to prevent backwards rotation of the fan during startup and to close when a fan fails or is stopped for service or maintenance. These dampers differ in material, thickness, seals, differential static pressure, and leakage rate. A damper can close by gravity or by linkages that operate the blades with a motorized actuator.

Manufacturers test dampers in accordance with ANSI/AMCA Standard 500-D, which determines air leakage, pressure drop, dynamic closure, and operational torque characteristics of a damper under uniform conditions.

Typically, fans in the array are stacked, so designers must select proper structural supports for each fan to minimize vibration. The operating frequency of the fan/motor needs to be selected outside of out of the natural or resonant frequency band of the isolator.

Designers should limit the motor size of each fan in the array to 30 HP and provide lifting point(s) or support to facilitate fan and motor replacement.

Redundancy and Variable Frequency Drives

The NIH *Design Requirements Manual* (*DRM*) specifies that designers shall provide multiple AHUs or exhaust fans for laboratories and critical facilities (*DRM* 6.1.8.1.B) to achieve N+1 equipment redundancy. By specifying that an array of direct-drive fans must still meet design airflow requirements if a fan in the array fails, designers can provide additional redundancy at the fan level. The level of fan redundancy required will be project- and application-specific.

System redundancy extends to the speed control for each fan. Per NIH *DRM* 6.2.8.2.1, the designer shall provide a variable frequency drive (VFD) for each primary and standby motor. The *DRM* also requires manual bypasses independent of the drive that permit full speed fan motor operation when the drive is deenergized; however, in an array that includes fan and AHU redundancy (N+1), VFD bypass is neither justified nor required. Where designers consider VFD bypass, they must carefully select direct-drive fans so the operating speed in VFD bypass mode does not exceed the maximum allowed fan rpm. *DRM* 6.2.4.2 requires that direct-drive fan motors operating with VFDs shall not operate above 90 Hz frequency and that motor size be based on operating frequency.

Improper selection may result in inefficient operation far from the operating point as well as excessive noise and duct pressurization. A single VFD shall not be used to control multiple fans within an AHU.

A current technology VFD can be mounted close to the air handling unit it serves, which minimizes motor circuit-conductor length issues that lead to damaging high peak voltages at the motor terminal.

Additional Reading

ASHRAE Handbook—HVAC Systems and Equipment (2020), ASHRAE
ASHRAE Laboratory Design Guide, 2nd Ed. (2015), ASHRAE
Direct-Drive Plenum Fans and Fan Arrays, Volume 39–1 (2010), Trane Engineers Newsletter