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Variable Frequency Drive (VFD) Control of Fans for Laboratory and Animal Research Facilities (ARFs)

Introduction

Variable Frequency Drives (VFDs) are typically used at NIH to control air handling units (AHUs) and exhaust fan systems. Advantages of VFDs include reduced energy cost from operating fans at reduced speeds in response to system load, the ability to set up and manage fan arrays or parallel or redundant fans, reduced motor inrush current during startup as VFDs start at lower speeds and ramp up, and a quick return on investment, typically achieved in less than 5 years.

Seamless Integration

The BAS shall provide for seamless integration with the control of VFDs and associated systems. The interface may be either hardwired (via point-by-point wiring to an applicable termination on the drive's interface board) or connected through digital communications via a controller network (e.g., a Siemens P1 chip or similar by Johnson and others included with the drive, a Modbus interface to the drive, or through BACnet communication protocol), or a combination of both.

At a minimum, the BAS shall hardwire interface with the AHU/exhaust VFDs for On/Off, speed control, and status.

Hand-Off-Auto (HOA) switch

An HOA switch shall be provided on the VFD. Any applicable fireman's override shall override any HOA switch function. Otherwise, the HOA shall control the fan as follows:

1. In the Hand position, the fan shall start and run continuously at a speed manually set on the drive unless a safety device trips. A mechanism shall be provided to open the dampers when the HOA is in the Hand position and will be proofed in the BAS.

2. In the Off position, the fan shall stop, and the dampers will shut.

BAS Fan Control

In the Auto position, the BAS shall control the fan as indicated below.

1. The VFD drive may have a bypass (across the line). The bypass position shall be monitored and annunciated as an alarm on the BAS. The application in bypass must include appropriate consideration of the operation in the bypass mode, such as operating point, ductwork pressurization, and noise.

2. On a direct drive operating in bypass mode (non-fan array), fans shall not be allowed to operate above their rated class RPM. Where fan operation with the VFD in bypass mode is not feasible, a backup VFD shall be provided to operate the direct drive motors in bypass mode.

3. On AHUs with multiple direct drive fans arranged in a fan array (fan wall), and where one fan is redundant (N+1), a backup VFD for each fan is not required. A bypass option is not recommended for VFDs serving direct drive fans arranged in a fan array.

4. Multiple fans within the AHU should not be controlled with common VFDs.

5. The BAS program shall control starting and stopping of the fans. Fans shall start at minimum speed and ramp up under a controlled rate to the required capacity. When fans stop, they shall ramp down from the control speed to minimum at a controlled rate prior to stopping.

6. Parallel fans powered by the VFD shall operate as lead/lag devices. When one device is commanded by the BAS to start, the lead device shall start and gradually ramp up in speed to maintain control set point.

7. When one fan fails, the VFDs start running the remaining fans at higher speeds to maintain control setpoint.

Fan Capacity Modulation

The BAS shall modulate the drive to maintain the design static pressure setpoint based on static pressure sensors located in the ductwork system. The response shall be based on the most demanding of multiple duct pressure sensors. The set point shall be reset based on terminal unit requirements.

Drive Configuration

Drive configuration shall include the following:

1. Automatic restart on power interruption

2. Acceleration and deceleration rates appropriate to the application

3. The drive shall catch the freewheeling fan and accelerate or decelerate to the required control frequency without stopping or going to a minimum speed first. This helps the fan to ride through the momentary power loss or voltage sag.

Communication Failure

Appropriate protections shall be programmed for communication failures. For instance, on loss of communication from the drive controller, the unit shall be controlled from last batch of data and the BAS shall provide an alarm. The BAS will also provide an alarm on failure of the VFD.

Conclusion

Proper control of the VFD-driven supply and exhaust fans is required to ensure efficient operation, proper airflow, and static pressure. In addition, the BAS ensures orderly startup, shutdown, and smooth operation.

References

1. NIH *DRM*, Chapter 7