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Field Testing Overview

This article provides an overview of field testing and how the principles contained in AMCA 203, Field Performance Measurement of Fan Systems, can be applied.

(The AMCA publications described in this article may be obtained from www.amca.org.)

The purpose of a field test is to define, via testing and measurement, the actual aerodynamic performance of a fan when installed in a system. Since installations often include elbows, obstructions, swirl and sudden changes in area, obtaining accurate measurements may be difficult. Additionally, these items may have an impact upon the unit's performance. This impact is called a system effect.

AMCA Field Test Publications

AMCA Publication 203 is a general purpose guide for the measurement of fan performance. This guide is applicable to most air handling equipment installed in any system. It includes the calculation process for loss in performance due to system effects and methods for calculating test results and uncertainties. A wealth of reference material and examples of typical applications pointing out where difficulties may be encountered are included.

People involved in field testing should also be familiar with AMCA's Certified Ratings Program outlined in Publication 211 and the concept of system effect factors (SEF) defined in AMCA Publication 201, Fans and Systems.

Reasons for Field Tests

Three main reasons for conducting a field test are —

1. General System Evaluation- A measurement of the fan and system's performance. This test may be used as a basis for future modifications or adjustment to the system.
2. Acceptance Test- A test specified in a sales agreement to verify that the fan is achieving the specified performance.
3. Proof of Performance Test- A test in response to a complaint to demonstrate that the fan is meeting the specified performance requirement.

Performance Rating Parameters

As already stated, the specific objective of a field test is to determine the aerodynamic performance of a fan when installed in a system. The operating point will occur at the intersection of the system resistance curve and the fan curve. Operation at any other point is impossible without altering either the fan or the system.

An operating point must be fully defined by obtaining test data that allows you to determine each of the following parameters:

1. Flow Rate - The fan flow rate is the volumetric flow rate corrected to the gas density at the fan inlet. The volumetric flow rate at any location in a system can be obtained by measuring the velocity pressure according to a specified grid in the plane of interest. The number and

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distribution of points is stipulated in AMCA 203. The flow in that plane is calculated by converting the average velocity pressure to its equivalent velocity and multiplying by the area of the traverse plane. The flow rate obtained in the measurement plane must be referred back to the fan inlet using the ratio of densities at the measurement plane to that of the fan inlet.

2. Fan Static Pressure - The fan static pressure is the algebraic difference between the static pressure at the fan outlet and the total pressure at the fan inlet. Static pressures using a pitot tube or static pressure taps are obtained near the fan outlet and fan inlet. The total pressure at the fan inlet is a measured value that consists of the sum of the inlet velocity and static pressures..

3. Fan Speed - This is the rotating speed of the fan shaft in revolutions per minute. Typically, measurements of fan speed are obtained at the beginning and end of a test and then averaged providing there is a small difference.

4. Fan Brake Horsepower - This is the power delivered to the fan shaft and does not include any drive losses other than the fan bearings. Nearly all field installations are driven by an electric motor in conjunction with a v-belt drive or variable frequency controller. Portable analyzers are available that read volts, amps, watts and power factor into the motor. Power out of the motor must be calculated using motor efficiency values or the ratio of actual amps and volts to nameplate values when the motor is at least loaded to 90% of full load. Fan brake horsepower values for units with v-belt drives must be calculated using the v-belt drive loss graph in Appendix L of AMCA 203. Units driven by a variable frequency controller must be by-passed to obtain accurate electrical values due to sine wave distortion. These values must then be corrected by the fan laws to the actual operating speed.

5. Fan Gas Density - The fan gas density is the density of the gas being handled at the fan inlet. The inlet density is calculated using the barometric pressure, wet and dry bulb temperature and corrections for suction or pressurized inlet conditions.

Calculation and Analysis of the Results

Detailed calculations are contained in AMCA 203 for obtaining test results. To compare test results with the factory-specified fan curve it is necessary to include SEF values, relevant drive losses, and speed and density corrections. The converted operating points can then be plotted on the factory-AMCA certified performance rating curve for analysis

An estimate of the individual uncertainties for each test parameter must be made. These can be combined to provide an overall uncertainty in flow, pressure and power. An error rectangle is then established around the test point using plus and minus absolute values of the combined uncertainties. Assuming the procedures from AMCA 203 are followed, combined uncertainties range as follows:

Volume	2% to 10%
Pressure	2% to 8%
Horsepower	4% to 8%

Summary

Greenheck products have a proven track record for performing to catalog levels, but keep in mind that the factory tests are conducted in ideal conditions.

Because fans are rarely installed in ideal conditions, field tests are frequently performed. For additional information on installation effects, see Greenheck's article FA/101-99, Understanding System Effects.

Product Application Binder

Application articles are available in print or can be found on our web site – www.greenheck.com, click on "Application Info".

To order an Application Binder fax 715-355-3119 or e-mail cheryl.aderhold@greenheck.com

Articles will be posted on the site upon completion and mailed twice a year to those individuals registered for a binder.

Industrial Heating Equipment Comparison and Evaluation

The purpose of this article is to provide an objective evaluation of five different gas-fired industrial space heating systems. Each evaluation offers a basic operational description, benefits and drawbacks. A comparison chart is included that rates each product on ten key rating categories.

With this information, you will be able to make better decisions on the type of heating system that is best suited for your specific application. In some cases, you will find that a combination of two or more of these heating technologies will provide the best overall heating system.

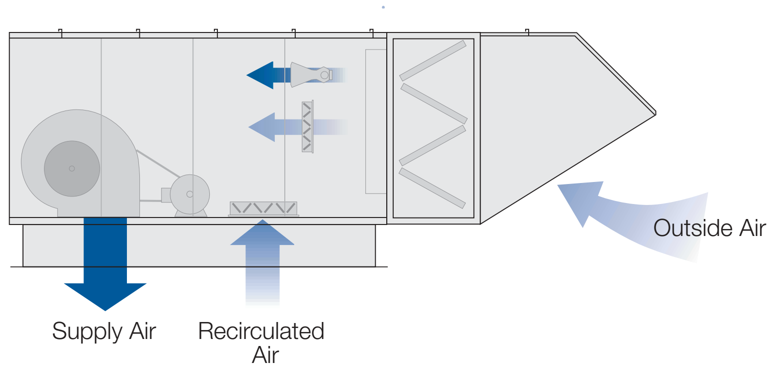
"80/20" Recirculation (Direct Gas-Fired)

Operation

Relatively high airflow volume turns the air about 1 time per hour. Supply air is a mixture of recirculated air and fresh outdoor air. Outdoor air varies from 20% to 100% of the supply, often configured to respond to building pressure sensing. Discharge temperatures typically range from 80° F to 110° F.

Benefits

- Excellent for facilities with mechanical exhaust systems, especially when the exhaust volume is variable
- A minimal number of units are required, even for large buildings
- Very uniform wall-to-wall heating with limited stratification
- Pressurizes building to offset cold air infiltration
- Provides reasonable summer ventilation
- Does not consume valuable floor space
- No heat exchanger efficiency loss



Drawbacks

- No zoning capabilities
- Open doors will drive 100% outdoor air operation, driving up fuel consumption and operating costs
- Recirculation mode may create condensation on uninsulated walls or cold material brought inside
- Not allowed in Canada
- High initial cost for buildings under 25,000 square feet

Comments

New ANSI standard restricts the amount of recirculation based on temperature rise. In most cases, a minimum of 30% outdoor air will be required.

High Temperature 100% Outdoor Air (Direct Gas-Fired)

Operation

A relatively low airflow volume is discharged at a high velocity and temperature (140° F). Supply air is 100% outdoor air. Relatively small heating units are spaced throughout the building.

Benefits

- Lowest initial cost in buildings over 25,000 square feet
- Low operating cost
- Excellent indoor air quality benefits
- Offsets cold air infiltration
- Very uniform wall-to-wall heating and limited stratification
- Does not consume valuable

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floor space
- Good zone heating capability
- Moisture from combustion improves indoor comfort
- Multiple units afford reasonable redundancy
- No heat exchanger efficiency loss

Drawbacks

- Additional equipment is required for summer ventilation
- May require gravity relief vent in very tight buildings
- High velocity throw may be annoying
- Moisture is a by-product of combustion that may cause condensation on objects brought in from cold outdoor conditions
- System design does not respond to a mechanically exhausted space

Comments

This is a relatively new technology that is rapidly gaining acceptance.

High Temperature 100% Outdoor Air (Direct Gas-Fired Unit)

Unit Heaters (Indirect Gas-Fired)

Operation

Provides "recirculated" warm air for spot heating. Typical configuration consists of a small package of a duct furnace and prop fan. Multiple unit heaters are spaced evenly throughout the building.

Benefits

- Good familiarity by installers and maintenance personnel
- Relatively simple to service
- Good redundancy
- Low equipment first cost
- Does not consume valuable floor space
- Good zone heating capability

Drawbacks

- No indoor air quality benefit (outdoor air only by infiltration)
- Unable to combat infiltration at dock doors
- Higher operating cost than direct gas-fired systems (70%-80% efficient versus 92% for direct gas)
- No summer ventilation benefit
- High installed initial cost for buildings over 25,000 square feet
- Ineffective at de-stratifying building air

Comments

Very mature technology that has changed very little in the past several decades.

Unit Heaters (Indirect Gas-Fired)

Air Rotation (Indirect Gas-Fired)

Operation

High airflow volume turns the air 1 1/2 to 2 1/2 times per hour. Air intake is near the floor and warm air is discharged out the top of the unit. An indirect gas-fired drum-and-tube heat exchanger provides a relatively low temperature rise of 40° F.

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Benefits

- Very few units are required, even for large buildings
- Fairly even heating with limited stratification
- Does not add moisture to the air, which eliminates condensation on cold objects or walls
- May be equipped with cooling coils
- Can be modified to provide outdoor air

Air Rotation (Indirect Gas-Fired)

Drawbacks

- Relatively high first cost
- No indoor air quality benefit if not equipped with outdoor air capabilities (most units are 100% recirculation only)
- If equipped for outdoor air, condensation and corrosion may shorten heat exchanger life
- Unable to combat infiltration at dock doors
- Cannot respond to a mechanically exhausted space
- Higher operating cost than direct gas-fired systems (70%-75% efficient versus 92% for direct gas)
- Consumes valuable floor space
- No zoning capabilities

Comments

Air rotation is a proven method for heating warehouses and factories. However, it is losing market share to direct gas-fired heating systems

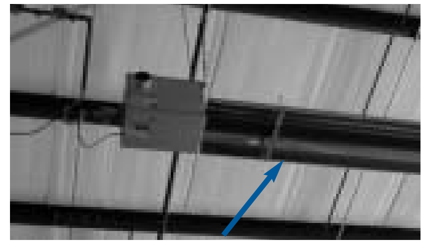
Radiant Tube (Indirect Gas-Fired)

Operation

A gas burner discharges into a tube. The tube becomes hot and radiates heat to the building floor and other objects. A rear reflector panel helps maximize radiation to the floor.

Benefits

- Excellent for heating a specific zone (relatively small area)
- Uniform comfort and draft free (as long as there is not mechanical exhaust or dock doors are open)
- Low operating cost
- Does not consume valuable floor space
- Keeps tools and equipment warm



Radiant Tube (Indirect Gas-Fired)

Drawbacks

- No indoor air quality benefit (outdoor air only by infiltration)
- Infiltration at dock doors and cracks will yield uneven heating
- No summer ventilation benefit
- No mixing to recover stratified heat near ceiling
- Dirt and dust on the tube and reflector reduces efficiency
- High initial installed cost when used for heating an entire building. Air curtains should be used for dock door applications to prevent drafts.
- Expensive replacement parts

Comments

Published efficiency is 85% to 92%. Actual operating efficiency is believed to be 70% to 80%.

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Industrial Space Heating System Comparison Table

	Direct Gas-Fired		Indirect Gas-Fired		
	"80/20" Recirculation	High Temperature 100% Outdoor Air	Unit Heaters	Air Rotation	Radiant Tube
Initial Cost (< 25,000 sq. ft.)	4	3	1	5	2
Initial Cost (> 25,000 sq. ft.)	2	1	4	3	5
Operating Cost	3	2	5	4	1
Indoor Air Quality Benefit	2	1	5	3	5
Infiltration Control	1	2	4	3	5
De-stratification	1	3	5	2	5
Zone Heating	5	3	2	5	1
Redundancy	4	3	2	5	1
Summer Ventilation Benefit	1	2	5	3	5
Usable Space Consumption	3	1	2	5	3
Average Rating	2.6	2.1	3.5	3.8	3.3

Scoring
1 = Most Favorable
5 = Least Favorable

Summary

Based on the overall rating average, the direct gas-fired products will generally provide the most desirable industrial space heating system by virtue of their favorable scoring in the areas of initial cost, operating cost, indoor air quality benefit, infiltration control, de-stratification, summer ventilation and useable space consumption. The high temperature 100% outdoor air system turns out to be the overall winner.

Unit heaters and infrared heaters received the most favorable marks in the areas of initial cost in small facilities, zone heating and redundancy. Air rotation, which is a generally accepted method of heating large industrial spaces, actually receives the lowest overall score.

It is important to acknowledge that no single heating product is superior in all areas. With each project, you should identify the most important heating benefits (using the above chart) and then select the appropriate product(s). As stated in the introduction, the right answer may be a combination of technologies (for example, high temperature 100% outdoor air units as the primary heaters in conjunction with infrared heaters above drive-in loading bays).

Suggested Air Changes for Good Ventilation

The most common method used to calculate cfm requirements for a given fan or fans is based on complete changes of air in a structure or room in a given time period.

To determine the cfm required to adequately ventilate an area, divide the room volume (in cubic ft.) by the appropriate "Minutes per Air Change" as shown in the adjacent chart.

Additional considerations when determining the number of air changes are:

- Local code requirements on air changes
- Specific use of the space
- The type of climate in the area

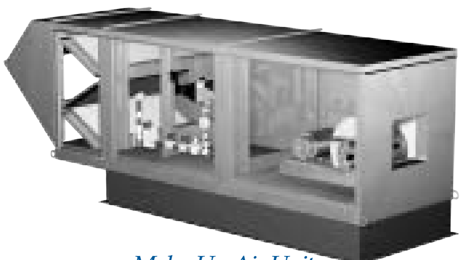
In the most severe conditions select the lower number (in the series shown) to change the air more frequently.

For moderate conditions, select the mid range. For less severe conditions in cool climates, the higher number will provide adequate ventilation.

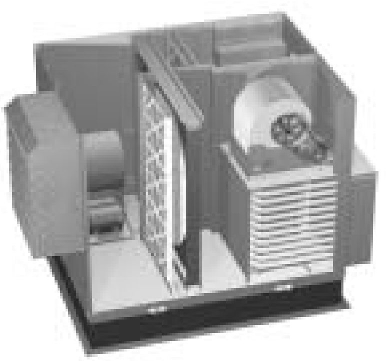
Type of Space	Minutes per Air Change
Assembly Halls	3 - 10
Attic	2 - 4
Auditoriums	4 - 15
Bakeries	1 - 3
Banks	3 - 10
Banquet Halls	3 - 4
Bar/Lounge	2 - 5
Barns	10 - 15
Beauty Parlors	2 - 5
Boiler Rooms	2 - 5
Bowling Alleys	2 - 8
Cafeteria	3 - 5
Church	4 - 10
Schools/Classroom	4 - 6
Club Room	3 - 7
Corridors/Halls	6 - 20
Dairies, Creameries	2 - 5
Dance Hall	3 - 7
Dining Rooms	3 - 6
Dormitories	5 - 8
Dry Cleaners	2 - 5
Engine Rooms	1 - 2
Factories (Light)	5 - 10
Factories (Heavy)	2 - 6
Forge Shops	1 - 3
Foundries	1 - 4
Garages	2 - 10
Generator Room	2 - 5
Glass Plants	1 - 2
Gymnasiums	3 - 8

Type of Space	Minutes per Air Change
Heat Treat Rooms	1 - 2
Hospital	4 - 6
Kitchens	2 - 4
Laboratory	2 - 5
Laundries	2 - 5
Locker Rooms	2 - 5
Lodge Rooms	3 - 5
Machine Shops	3 - 5
Meeting Rooms	4 - 6
Mill (General)	3 - 8
Mills (Paper)	2 - 3
Mills (Textile)	5 - 15
Office	2 - 8
Packing Houses	2 - 5
Plating Rooms	1 - 5
Printing Plants	3 - 8
Projection Room	1 - 2
Recreation Rooms	2 - 8
Residences	3 - 6
Restaurants/Dining Rooms	3 - 7
Restrooms	3 - 6
Retail Stores	3 - 8
Ship Holds	8 - 10
Shops (General)	3 - 10
Theaters	3 - 8
Transfer Room	1 - 5
Transformer Rooms	1 - 5
Tunnels	6 - 10
Turbine Rooms	2 - 6
Warehouses	3 - 10

What's new at Greenheck



Make-Up Air Unit
Model DGX



Energy Recover Ventilator
Model ERH

Greenheck Introduces Direct Gas

Greenheck's new X-series of modular Make-Up Air units provide flexibility at competitive prices. The new units include Model DGX, a direct gas-fired unit designed for providing heated make-up air to commercial and industrial facilities.

Model DGX provides larger housing sizes and increased capacity to 23,000 cfm, greater mechanical and evaporative cooling capacities, and more industrial space heating capability. A flexible modular design concept enables each product to be customized for its application.

New Energy Recovery Model ERH

The ERH product offers energy recovery with heating at a lower cost than the ERCH. And, compared to the ERCH, it is physically smaller and lighter.

Model ERH features include:

- 20% lower price than the ERCH
- Hot water, electric or indirect gas heating
- Standard double wall construction
- Airflow from 1,000 cfm to 10,000 cfm
- Fans are forward curved
- Static pressure capabilities up to 2.0 in. wg

A manual discharge controller is available on the ERH. The controller is pre-wired from the factory and allows the user to set the discharge temperature of the heater at the unit's control panel. This manual controller provides an economical means of controlling the discharge temperature of the heater.

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