System Effects

Matthew Spink, P.E.
Product Manager
Centrifugal, Vane Axial, and Industrial Products
Greenheck Fan Corporation
Design Airflow

Design System Curve

Catalog Fan Curve

\[ \text{PS} \]

\[ \text{CFM} \times 1000 \]
Fan Curves

• Show how a fan will operate in any system (installation)

• Based on standardized tests
  – AMCA 210

• Tested under ideal conditions
System Effects Defined:

• Anything you place in close proximity before or after the fan that effects the cataloged performance.
System Effects
Actual Airflow

Catalog Fan Curve

System Curve

Actual Fan Curve

PS

CFM x 1000
Why System Effect is Important

- Can decrease performance
- Can cause excess vibration
- Can cause excess noise
- Can require more energy (HP) to achieve rated performance
- Takes time to determine and understand
Three most common causes of deficient performance of a fan/system are:

- Improper outlet connections
- Non-uniform inlet flow
- Swirl at the inlet
Fan Outlet Velocity Profiles

Adapted from AMCA Publication 201-202, *Fans and Systems.*
Effective Duct Length

Effective Duct Length = 2.5 Duct Diameters for 2,500 FPM or less

Add 1 duct diameter for each additional 1,000 FPM

For rectangular ducts, the equivalent duct diameter is

\[(4 \times \text{width} \times \text{length} / 3.14)^{0.5}\]
System Effect Curve

Adapted from AMCA Publication 201-202, *Fans and Systems*. 

(Air Density = 0.075 lbf/ft³)
System Effect Curves for Outlet Ducts - Centrifugal Fans

Adapted from AMCA Publication 201-202, *Fans and Systems*. 

<table>
<thead>
<tr>
<th>Blast Area Outlet Area</th>
<th>System Effect Curve</th>
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</thead>
<tbody>
<tr>
<td>0.4</td>
<td>P R-S U W --</td>
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<tr>
<td>0.5</td>
<td>P R-S U W --</td>
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<td>0.9</td>
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</table>
System Effect Curve

+0.45 in w.g.

Adapted from AMCA Publication 201-202, *Fans and Systems*. 
Outlet Conditions

Good

Poor
Outlet Elbows

Better

Poor
Outlet Elbows - Centrifugal Fans

Adapted from AMCA Publication 201-202, Fans and Systems.
Example:

- 22-BISW
- 12,000 CFM (4,200 fpm)
- 2 in w.g.
- blast/outlet ratio = 0.7
- 2016 rpm
- 12.35 bhp (15 hp motor)

Outlet System Effect?
# System Effect Curves for SWSI Fans

<table>
<thead>
<tr>
<th>Blast Area</th>
<th>Outlet Elbow Position</th>
<th>No Outlet Duct</th>
<th>12% Effective Duct</th>
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Adapted from AMCA Publication 201-202, *Fans and Systems*. 

[Diagram of outlet and elbow positions]
System Effect Curve

Adapted from AMCA Publication 201-202, *Fans and Systems*. 
# System Effect Curves for SWSI Fans

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Adapted from AMCA Publication 201-202, _Fans and Systems_.

AMCA International Publication 201-90
System Effect Curve

Adapted from AMCA Publication 201-202, *Fans and Systems.*
Outlet Elbows - Centrifugal Fans

Position D
+2 in w.g.

Position C
+2 in w.g.

Position B
+1.3 in w.g.

Position A
+1 in w.g.

Outlet Elbows - Centrifugal Fans

Position D
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Outlet Elbows - Centrifugal Fans

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Outlet Elbows - Centrifugal Fans

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Position A
+1 in w.g.
Three most common causes of deficient performance of a fan/system are:

- Improper outlet connections
- Non-uniform inlet flow
- Swirl at the inlet
Inlet Conditions

Inlet with 3-piece elbow

Inlet with rectangular inlet Duct

Inlet with special designed inlet box
System Effect - Square elbow and turning vanes

Adapted from AMCA Publication 201-202, *Fans and Systems*.
System Effect Curve

Adapted from AMCA Publication 201-202, *Fans and Systems*. 
System Effect on round inlet ducts

System Effect Curves

<table>
<thead>
<tr>
<th>R/D</th>
<th>No Duct</th>
<th>2D Duct</th>
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<tr>
<td>3.0</td>
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</table>

2 piece mitered round section

3 piece mitered round section

4 or more piece mitered round section

Adapted from AMCA Publication 201-202, Fans and Systems.
System Effect Curve

Adapted from AMCA Publication 201-202, *Fans and Systems.*
Three most common causes of deficient performance of a fan/system are:

• Improper outlet connections

• Non-uniform inlet flow

• Swirl at the inlet
Inlet Swirl

Pre-Rotation

Counter-Rotation
Inlet Swirl

Best solution for inlet swirl is turning vanes.
The CALL !!!

“My fan isn’t performing, come fix it.”

“I ordered 3,000 cfm at 1 inch
Balancer said I have 2,500 at 3/4 inch.”
What's the PROBLEM?

- Fan?
- Motor?
- Inlet conditions?
- Outlet conditions?

Let's Look at Installation!!!
**Back to The CALL!**

Givens:
- Centrifugal Fan
- 3,000 cfm at 1 inch static pressure
- 13 by 13 inch fan discharge / duct size
- 9 by 13 inch blast area
- **NO** duct length after discharge

- 3,000 cfm / (13 x 13) = 2556 FPM

- Equiv. Duct Dia. = \((4 \times 13 \times 13 / 3.14)^{0.5} = 14.5\) inches
  
  **Effective duct length** = 2.5 + 1 = 3.5 ducts = 3.5 x 14.5 inches = 4 ft

- Blast Area / Outlet Area = (9 x 13) / (13 x 13) = 0.7
System Effect Curves for Outlet Ducts - Centrifugal Fans

Adapted from AMCA Publication 201-202, Fans and Systems.
System Effect Curve

System Effect Factor (no duct) ~ 0.3 inches

Adapted from AMCA Publication 201-202, Fans and Systems.
Solution?

- Increased BHP
- BHP
- Expected
- Actual
- Increased RPM

Ps vs CFM graph showing the comparison between expected and actual performance, with the solution indicating increased BHP and RPM.
Back to The CALL!

Givens:
• Centrifugal Fan
• 3,000 cfm at 1 inch static pressure
• 13 by 13 inch fan discharge / duct size
• 9 by 13 inch blast area

• What if they placed a 12 inch duct after the discharge?

(1 ft of duct length = 25% of the effective length)
System Effect Curves for Outlet Ducts - Centrifugal Fans

Adapted from AMCA Publication 201-202, *Fans and Systems.*
System Effect Curve

No system effect with 25% effective duct length

Adapted from AMCA Publication 201-202, *Fans and Systems.*
Nice Work!
Flow Probe System Effect

Plenum Fan
Typical Flow Probes

- Mounted into the smallest diameter of the fan inlet venturi
- Use 3/8" to 3/4" tubing that is designed to measure total and static pressure components of airflow
Flow Probe System Effect Video
General Rules of Thumb

• Minimum 2.5 duct diameters on Outlet
• Minimum 5 to 8 duct diameters on Inlet
• Avoid inlet swirl

  - If any of these general rules are broken, be aware of the system effect results
Thank You for your Time

Matthew Spink, P.E.
Greenheck Fan Corporation