Selecting Laboratory Exhaust Fans to Meet Projects' Acoustical Criteria

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Webinar Moderator

- Joined AMCA in February 2019
- Responsible for development of AMCA’s education programs; staff liaison for the Education & Training Committee
- Projects include webinars, AMCA’s online learning platform programming, presentations at trade shows, PDH/RCEP account management, and AMCA’s Speakers Network

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  - Questions can be submitted anytime via the GoToWebinar platform and will be addressed at the end of the presentation.
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  - To earn PDH credit for today, please stay clicked onto the webinar **for the entire hour**.
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Q & A

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- From the attendee panel on the side of the screen, select the "Questions" drop down option.
- Type your question in the box, indicating to whom your question is for.
- Click "Send".

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Doug Ross

Business Development Manager,
AMCA Member Company

- Automation & Control Engineer from Auckland Technical Institute in New Zealand; moved to Canada in 2000
- Working in the Air Movement industry since 2005
- Focus on laboratory exhaust system design, especially in critical environment applications

Kristen Neath

Canadian National Sales Manager – Commercial, Industrial & Environmental, AMCA Member Company

- Expertise in reducing mechanical HVAC noise through design & application of noise control products
- Extensive knowledge of sheet metal design & fabrication
- Bachelors of Engineering in Mechanical Systems Engineering

Selecting Laboratory Fans Meeting Acoustical Criteria of the Project

Purpose and Learning Objectives

The purpose of this presentation is to explain exhaust systems for critical environments and the alternatives to N+1 redundancy, and how they provide significantly improved operating efficiency, smaller footprint, and better control.

At the end of this presentation you will be able to:

1. Identify an alternative to N+1 redundancy for critical systems.
2. Explain how N-1 vs. N+1 results in a system that is easier to control, with a smaller footprint and lower upfront cost.
3. Outline some of the key components in silencer selection.
4. Describe what sound propagation is and what factors affect it.

Understanding N+1 and N-1 Configuration

Benefits associated with N-1 vs. N+1:

- Faster system response to fan failure
- Greater system stability / staging capability
- Comparable energy consumption/cost
- Better airflow/energy transfer over ERU coil and often ….
- Smaller system size (footprint)
- Reduced weight
- Lower first cost

Per Merriam-Webster:

Redundancy -

"technical **:** a part in a machine, system, etc., that has the same function as another part and that exists so that the entire machine, system, etc., will not fail if the main part fails"

re·dun·dan·cy

/rəˈdəndənsē/

noun

the state of being not or no longer needed or useful.

"the redundancy of 19th-century heavy plant machinery"

- BRITISH

  the state of being no longer employed because there is no more work available.

  plural noun: **redundancies**

  "the factory's workers face redundancy"

- ENGINEERING

  the inclusion of extra components which are not strictly necessary to functioning, in case of failure in other components.

  "a high degree of redundancy is built into the machinery installation"

Ensuring Safe Operation of Critical Applications

- Since laboratory exhaust systems are critical to the safe operation of the building, redundancy is typically designed in by having enough fans in a given system so that with one fan offline, the other fans can carry the load.

Ensuring Safe Operation of Critical Applications

The N+1 concept has been traditionally employed wherein there is an idle back-up fan which can be brought online in the event that an operating fan fails or goes offline.

Ensuring Safe Operation of Critical Applications

Issues associated with N+1:

Control

System stability

Periodic fan cycling recommended (good PM)

Airflow over ERU coil

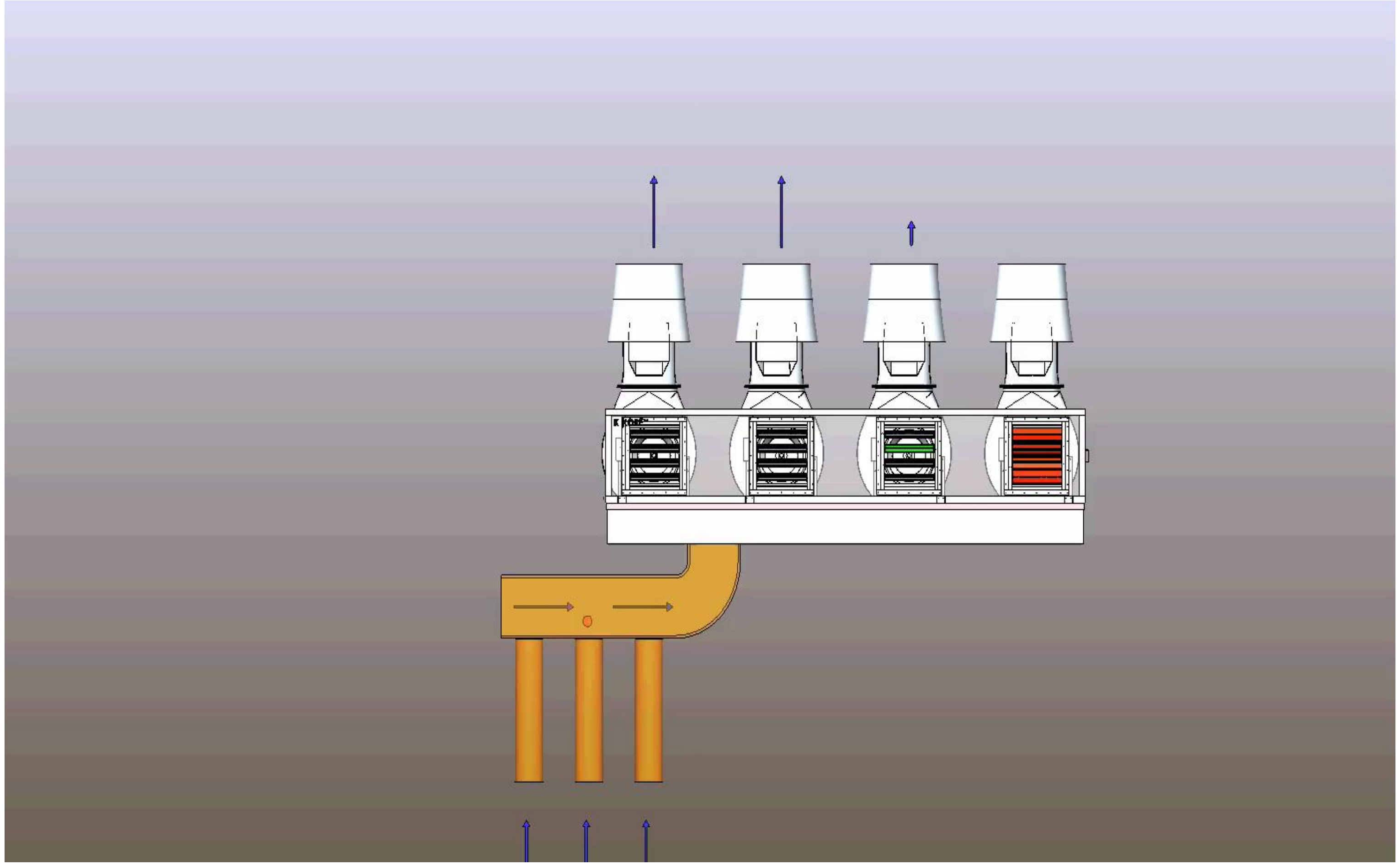
Ensuring Safe Operation of Critical Applications

Starting an idle fan takes time (the larger the fan the more time)

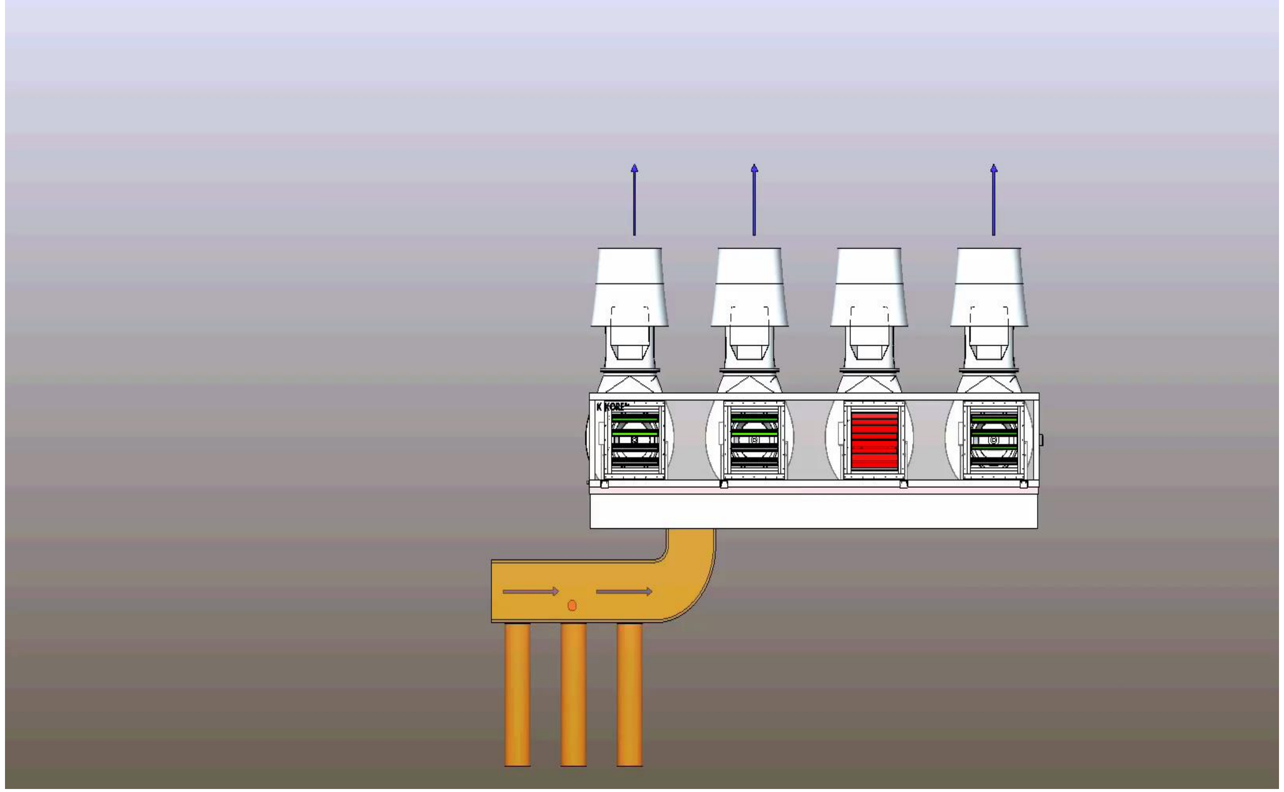
Offline fan isolation damper closes

Back-up fan isolation damper opens

Back-up fan energizes, overcomes starting moment, and ramps up to operating speed



Ensuring Safe Operation of Critical Applications



Depending on the control sequence, the process of cycling in the idle fan can take several seconds up to more than a minute. Accordingly, the system will lose pressure, perhaps going into alarm.

Ensuring Safe Operation of Critical Applications

Depending on the control sequence, after several seconds the system SP is achieved and returned to stable operation.

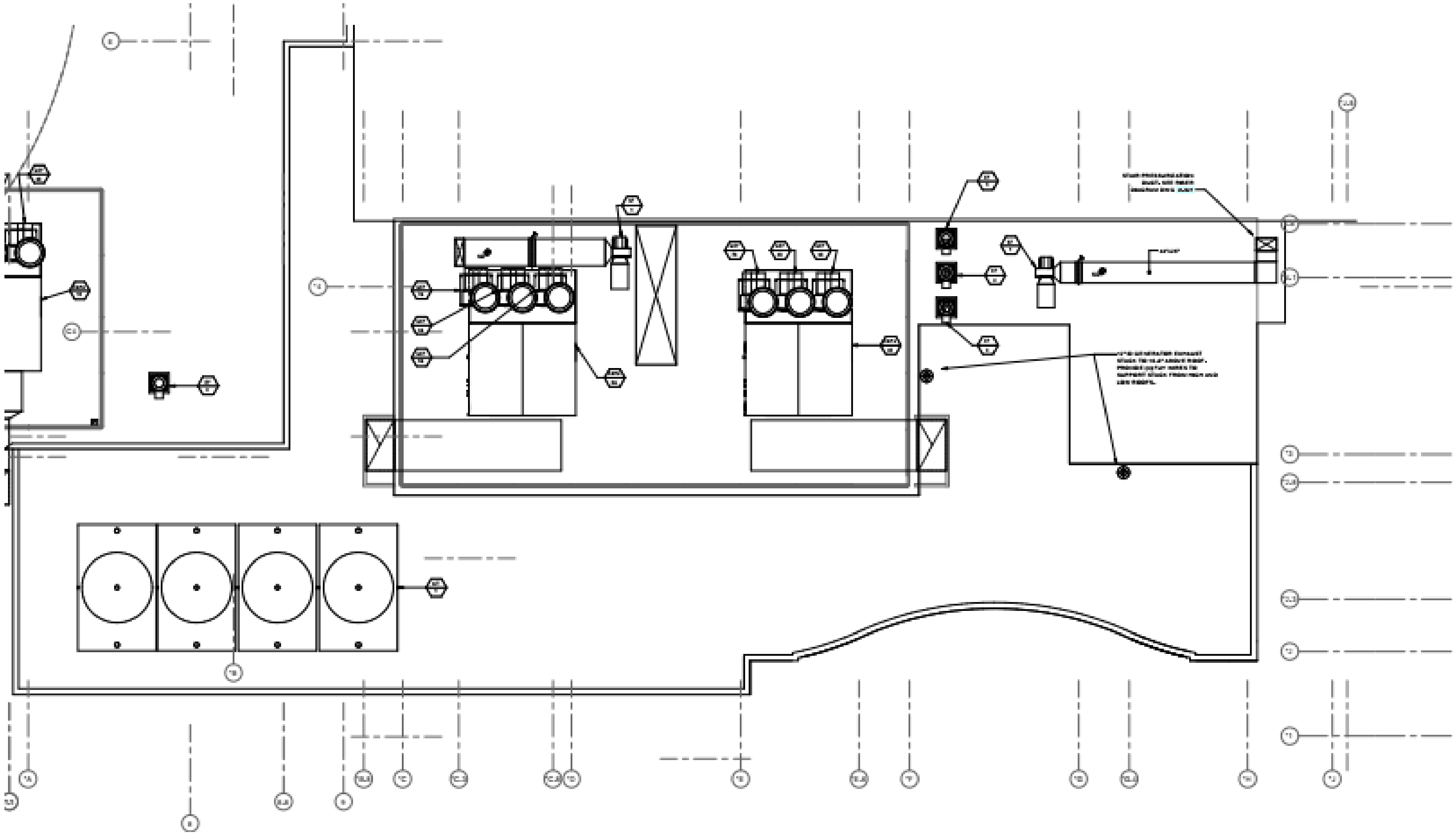
In normal operation, with an idle fan on an energy recovery plenum, there may be areas of low velocity over the coil which can diminish the system's efficiency.

Criteria outline for design of Laboratory Exhaust System

I am designing a lab ventilation system which uses negative pressure control by modulating exhaust volume from the laboratory areas. The total airflow for the laboratory area is 60,000 CFM with 4.5” w.c. TSP. The exhaust is discharged through a high plume dilution exhaust fan to maintain a discharge velocity of 3000 fpm.

Please note that the fan exhaust volume needs to be kept constant to maintain the discharge velocity of 3000 fpm. There is a by-pass damper at the fan inlet to maintain the discharge velocity when the room exhaust volume varies due to operational requirements and night-time setbacks. What is the best way to control the system?

Selecting a suitable High Plume Dilution fan



Selecting a suitable High Plume Dilution fan

Known Parameters

- Total Max Flow = 60,000 CFM
- Total Static Pressure = 4.5” w.c.
- Nozzle Velocity ≥ 3000 fpm
- Design Guide ANSI/AIHA/ASSE Z9.5 2012
- FEG > 67 (ASHRAE 90.1 2015)
- FEI > 1.00(ASHRAE 90.1 2019)

Assumed Parameters

- Minimum Flow = 36,000 CFM
- Available Roof space - TBA
- Sound Requirements ≤ 75dB(A) @ 100ft
- Exhaust gases – Wet Chemistry Labs
- Dilution and Dispersion Requirements - TBA

Utilizing the N+1 Configuration Concept

- 3 Fans operating in N + 1 operation

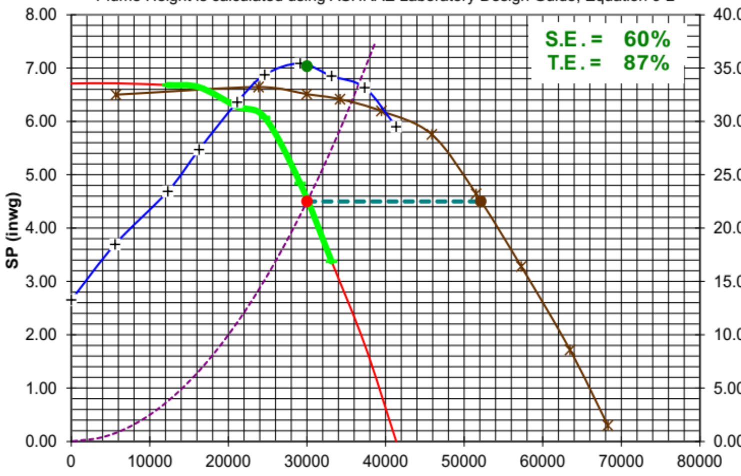
Date	.	Model	AXIJET		10 [mph]
Sys. No.	.	Fan Size	4450	EH =	61.5 [feet]
	.	Dia.[in]	44.50	PH =	44.9 [feet]
	.	CFM	30000	NV =	5597 [fpm]
		SP	4.5	WV =	2612 [fpm]
Drawing	. A	BHP	35.18	TF =	52119 [cfm]
Revision	.	RPM	996	TS =	11603 [fpm]
				T =	70 [°F]
				ALT =	0 [feet]

FEI_T Based on
Default Motor Efficiencies
Regulated Motor Efficiencies

Air performance FEI_T = 1.40

CLASS II WHEEL

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed
EH: Effective Plume Height. (Plume Height + Fan Height)
Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2



Density : 0.075 lb/ft³

CFM-SP
System Curve
CFM-BHP
Total Flow-SP

FEG90

Performance shown is for installation type C: Ducted inlet, Free outlet. Power rating (BHP) does not include transmission losses. Performance ratings do not include the effects of appurtenances (accessories). Performance ratings do not include the effects of crosswinds. FEI values are calculated in accordance with AMCA 208 and are based on default motor efficiencies. FEI values for fans with specific motors will vary slightly from those shown.

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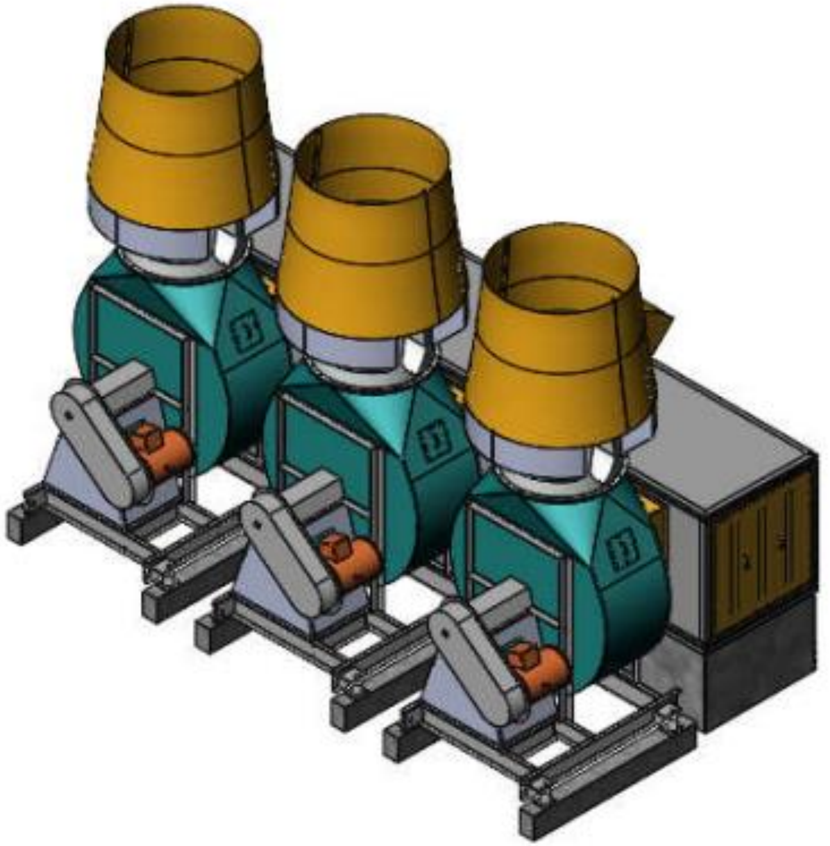
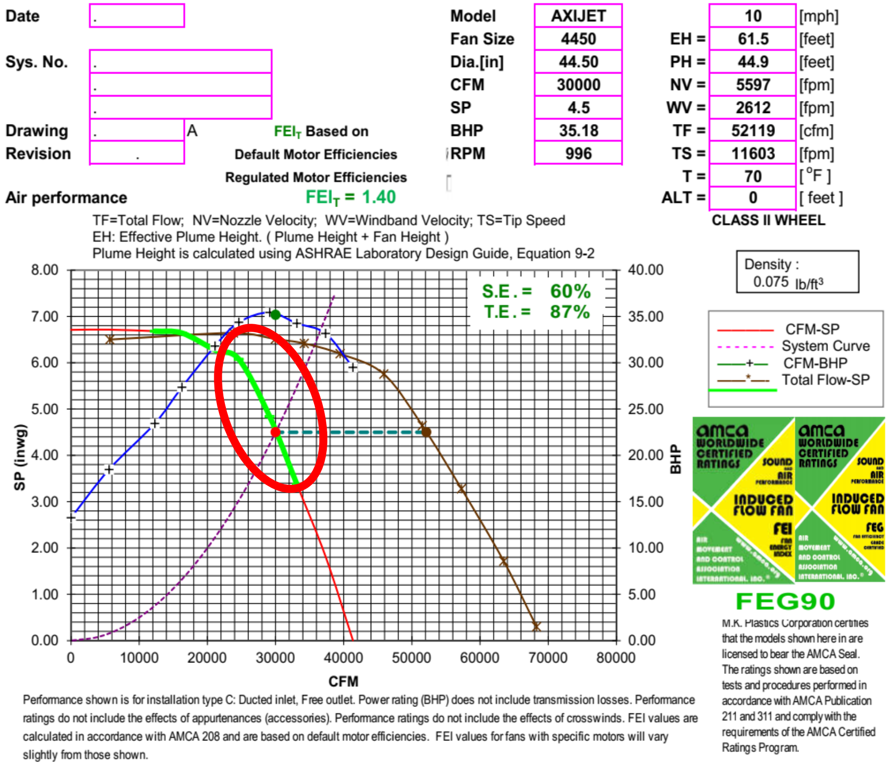


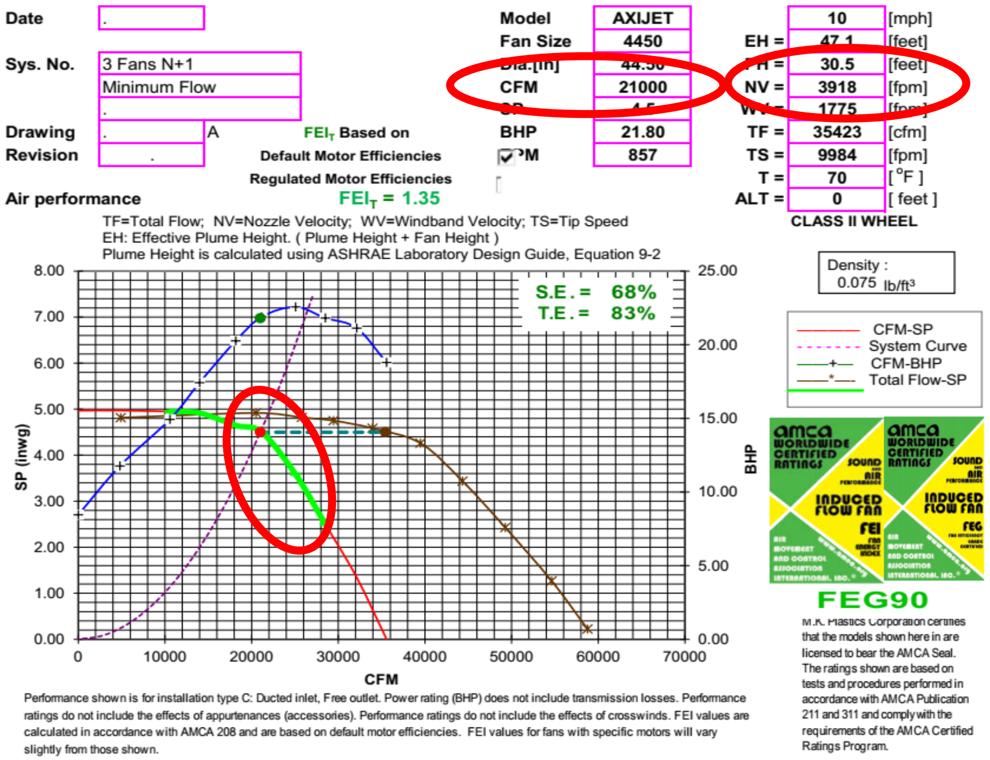
Utilizing the N+1 Configuration Concept

- 3 Fans operating in N + 1 operation

Minimum volume or turn down performance while maintaining 3,000 fpm nozzle velocity



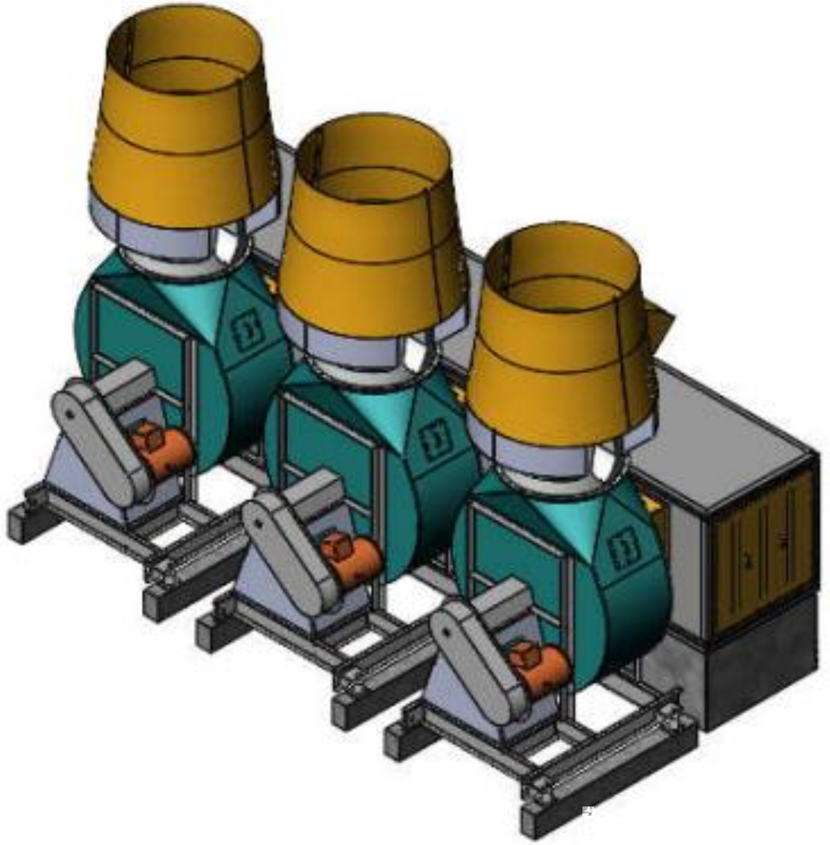
Minimum Flow with fan operating in stable condition



Utilizing the N+1 Configuration Concept

- 3 Fans operating in N + 1 operation annual energy cost

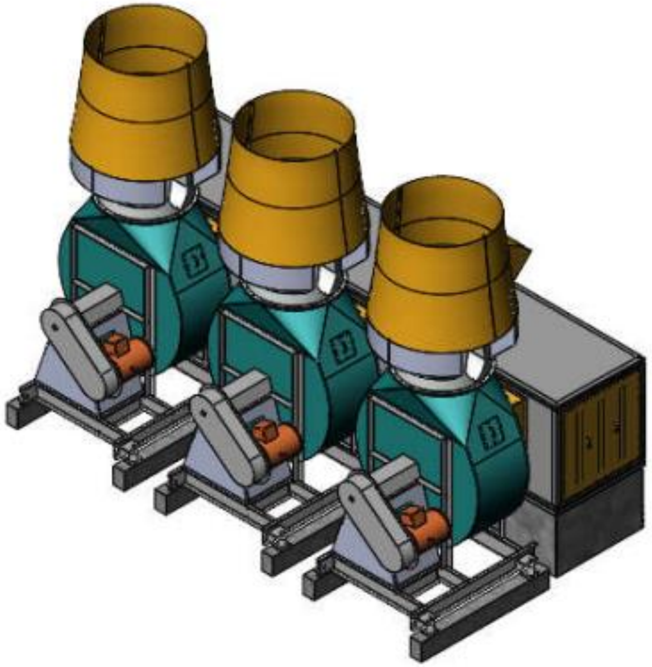
	$/kW hr.	$0.10							
	Capacity Utilization	100%	90%	80%	70%	60%	50%		
	% time used	5%	10%	20%	40%	15%	10%	100%	Annual System Energy Cost
Design/VFD controlled IFF (plume) fans/N+1	Concept								
M.K. Plastics AxiJet 4450	Mfg/Model								
Tag# LEF 1A,B,C	Tag #								
	System CFM	60000	54000	48000	42000	36000	27000		
	SP ("wg)	4.5	4.5	4.5	4.5	4.5	4.5		
	Motor HP	40	40	40	40	40	40		
	# fans total	3	3	3	3	3	3		
	Connected HP	120	120	120	120	120	120		
	# fans running	2	2	2	2	2	1		
	CFM/fan	30000	27000	24000	21000	18000	27000		
	System bypass CFM	0	0	0	0	0	0		
	NV (fpm)	5597	5037	4478	3918	3358	5037		
	Fan RPM	996	950	899	851	807	950		
	BHP/fan	35.18	31.87	26.65	22.18	18.26	31.87		
	BHP/total	70.36	63.74	53.30	44.36	36.52	31.87		
	% time used	5%	10%	20%	55%	0%	10%	100%	
	Weighted BHP	3.52	6.37	10.66	24.40	0.00	3.19		$31,371



Utilizing the N+1 Configuration Concept

- 3 Fans operating in N + 1 operational data

System statistics for N+1 Configuration															
Operating Conditions							Motor					Package Information			Energy
Condition	Exhaust Volume (CFM)	Static Pressure (inch w.c.)	# Fans	# Fans operating	CFM/Fan	Fan Model	Fan dB(A) @ 10 Ft	BHP/Fan	Motor HP/Fan	Operating BHP	Connected Motor HP	Total Weight Fan, Motor and Plenum (lbs)	Width (Ft)	Length (Ft)	Footprint Fans and Plenum (SqFt)	Annual System Energy Cost ($0.10 /kW hr)
Normal	60,000	4.5	3	2	30,000	4450	54+3=57	35.18	40	70.36	120	11,774	17.2	25.4	436.88	$31,371
Emergency																



Utilizing the N -1 Configuration Concept

Selecting a suitable High Plume Dilution fan

Known Parameters

- Total Max Flow = 60,000 CFM
- Total Static Pressure = 4.5” w.c.
- Nozzle Velocity ≥ 3000 fpm
- Design Guide ANSI/AIHA/ASSE Z9.5 2012
- FEG > 67 (ASHRAE 90.1 2015)
- FEI > 1.00(ASHRAE 90.1 2019)

Assumed Parameters

- Minimum Flow = 36,000 CFM
- Available Roof space - TBA
- Sound Requirements ≤ 75dB(A) @ 100ft
- Exhaust gases – Wet Chemistry Labs
- Dilution and Dispersion Requirements - TBA

Utilizing the N -1 Configuration Concept

- 4 Fans operating in N -1 operation

Date	.	Model	AXIJET
		Fan Size	3000
Sys. No.	LEF - 1A;1B;1C;1D	Dia.[in]	30.00
	4 Fan N-1 Operation	CFM	15000
	60,000 CFM System Flow	SP	4.5
Drawing	. A	BHP	20.57
Revision	.	RPM	1588

FEI_T Based on

Default Motor Efficiencies ☑

Regulated Motor Efficiencies ☐

	10	[mph]
EH =	41.8	[feet]
PH =	31.0	[feet]
NV =	6173	[fpm]
WV =	2681	[fpm]
TF =	24279	[cfm]
TS =	12472	[fpm]
T =	70	[°F]
ALT =	0	[feet]

CLASS II WHEEL

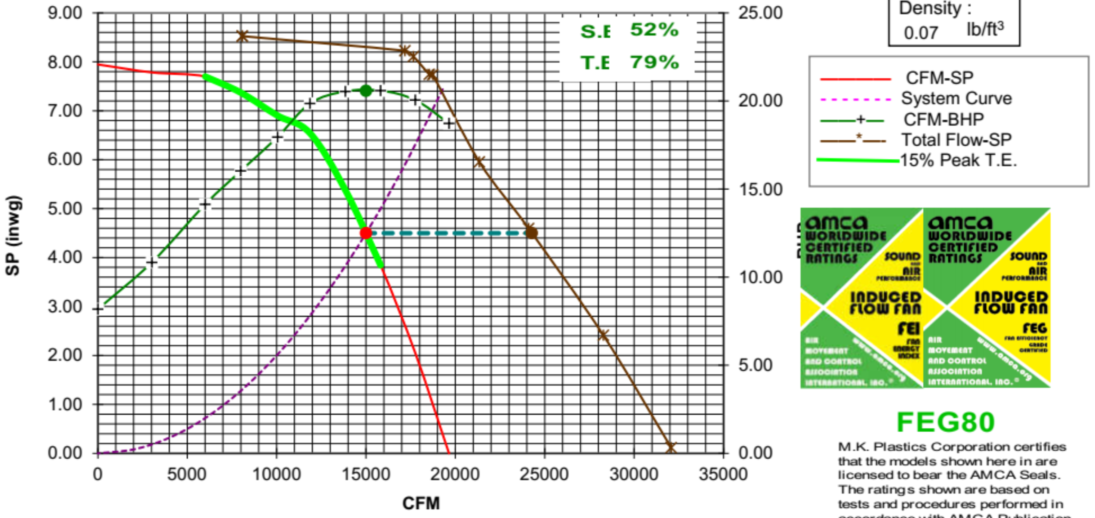
Air performance

FEI_T = 1.28

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed

EH: Effective Plume Height. (Plume Height + Fan Height)

Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2



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FEG80

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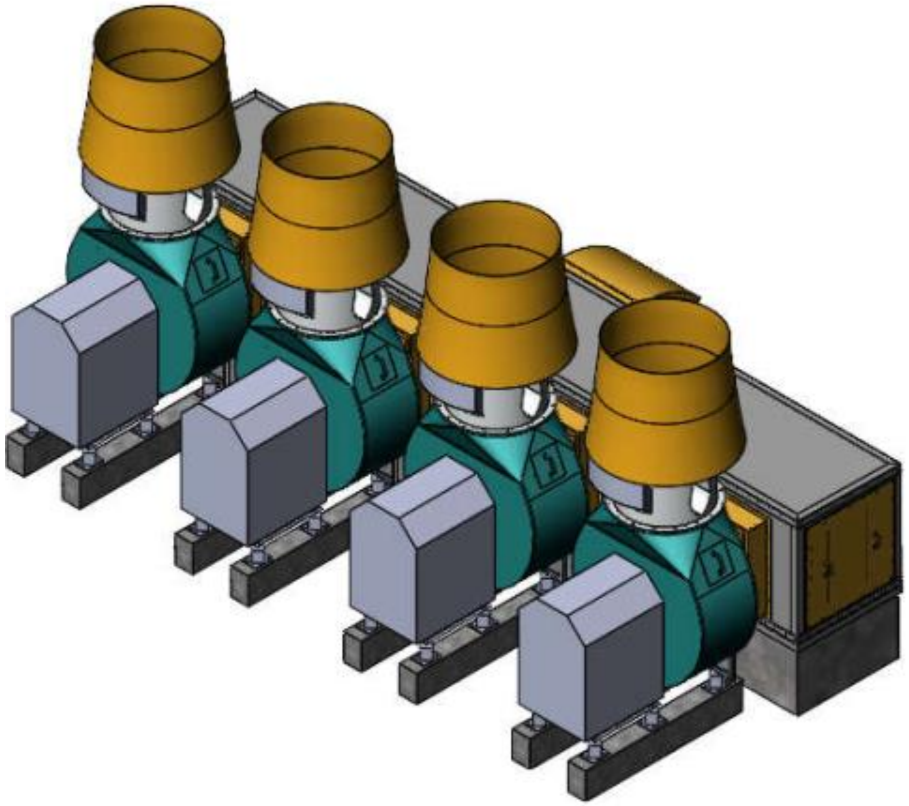


Utilizing the N -1 Configuration Concept

- 4 Fans operating in N -1 operation

Minimum volume or turn down performance while maintaining 3,000 fpm nozzle velocity

Emergency Operation with 3 fan operating in stable condition

Date	.	Model	AXIJET		10	[mph]
		Fan Size	3000	EH =	41.8	[feet]
Sys. No.	LEF - 1A;1B;1C;1D	Dia.[in]	30.00	PH =	31.0	[feet]
	4 Fan N-1 Operation	CFM	15000	NV =	6173	[fpm]
	60,000 CFM System Flow	SP	4.5	WV =	2681	[fpm]
Drawing	. A	BHP	20.57	TF =	24279	[cfm]
Revision	.	RPM	1588	TS =	12472	[fpm]
				T =	70	[°F]
				ALT =	0	[feet]

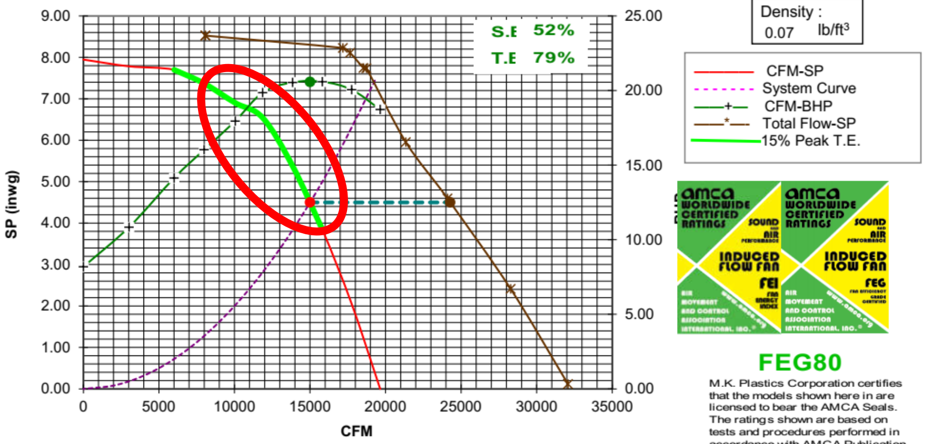
FEI_T Based on
Default Motor Efficiencies ☑
Regulated Motor Efficiencies ☐

Air performance FEI_T = 1.28

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed
EH: Effective Plume Height. (Plume Height + Fan Height)
Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2

CLASS II WHEEL

Density : 0.07 lb/ft³



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Date	.	Model	AXIJET		10	[mph]
		Fan Size	3000	EH =	52.3	[feet]
Sys. No.	LEF - 1A;1B;1C;1D	Dia.[in]	30.00	PH =	41.5	[feet]
	4 Fan N-1 Operation	CFM	20000	NV =	8230	[fpm]
	60,000 CFM System Flow	SP	4.5	WV =	3586	[fpm]
Drawing	. A	BHP	35.62	TF =	32475	[cfm]
Revision	.	RPM	1913	TS =	15025	[fpm]
				T =	70	[°F]
				ALT =	0	[feet]

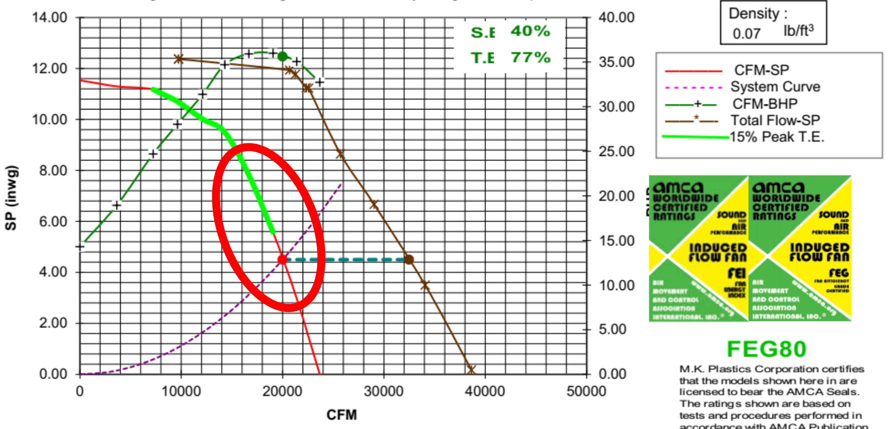
FEI_T Based on
Default Motor Efficiencies ☑
Regulated Motor Efficiencies ☐

Air performance FEI_T = 1.23

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed
EH: Effective Plume Height. (Plume Height + Fan Height)
Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2

CLASS III WHEEL

Density : 0.07 lb/ft³



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Utilizing the N -1 Configuration Concept

- 4 Fans operating in N -1 operation

Minimum volume or turn down performance while maintaining 3,000 fpm nozzle velocity

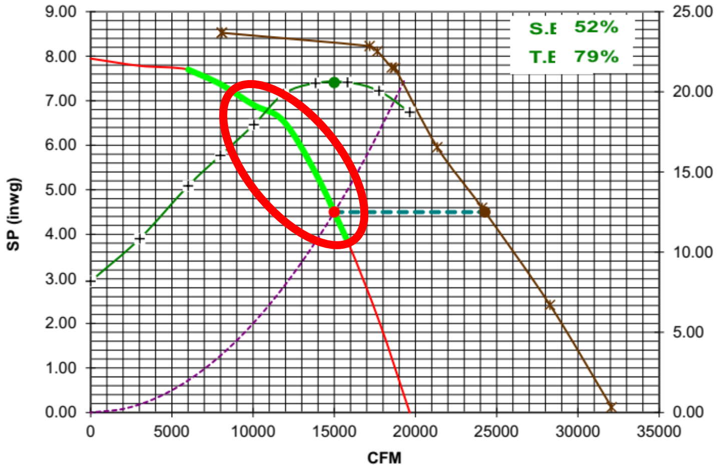
Date	.	Model	AXIJET		10 [mph]
		Fan Size	3000	EH =	41.8 [feet]
Sys. No.	LEF - 1A;1B;1C;1D	Dia.[in]	30.00	PH =	31.0 [feet]
	4 Fan N-1 Operation	CFM	15000	NV =	6173 [fpm]
	60,000 CFM System Flow	SP	4.5	WV =	2681 [fpm]
Drawing	. A	BHP	20.57	TF =	24279 [cfm]
Revision	.	RPM	1588	TS =	12472 [fpm]
				T =	70 [°F]
				ALT =	0 [feet]

FEI_T Based on Default Motor Efficiencies ☑ / Regulated Motor Efficiencies ☐

Air performance FEI_T = 1.28

CLASS II WHEEL

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed
EH: Effective Plume Height. (Plume Height + Fan Height)
Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2



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Minimum Flow with fan operating in stable condition

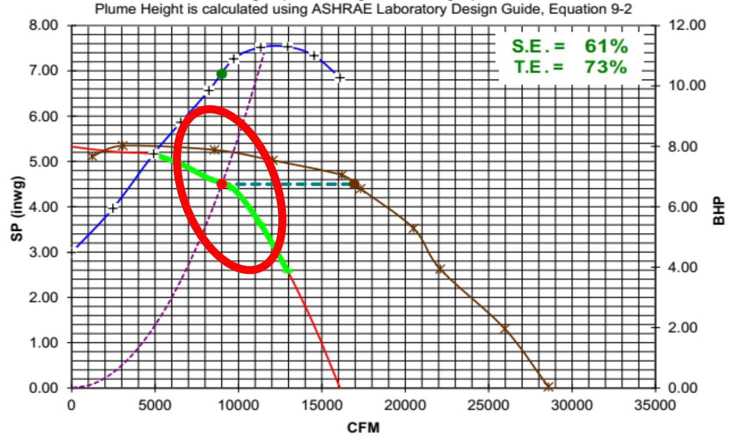
Date	.	Model	AXIJET		10 [mph]
		Fan Size	3000	EH =	32.5 [feet]
Sys. No.	4 Fans N-1	Dia.[in]	30.00	PH =	21.7 [feet]
	Minimum Flow	CFM	9000	NV =	3704 [fpm]
	.	SP	4.5	WV =	1871 [fpm]
Drawing	. A	BHP	10.40	TF =	10942 [cfm]
Revision	.	RPM	1300	TS =	10210 [fpm]
				T =	70 [°F]
				ALT =	0 [feet]

FEI_T Based on Default Motor Efficiencies ☑ / Regulated Motor Efficiencies

Air performance FEI_T = 1.22

CLASS II WHEEL

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed
EH: Effective Plume Height. (Plume Height + Fan Height)
Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2



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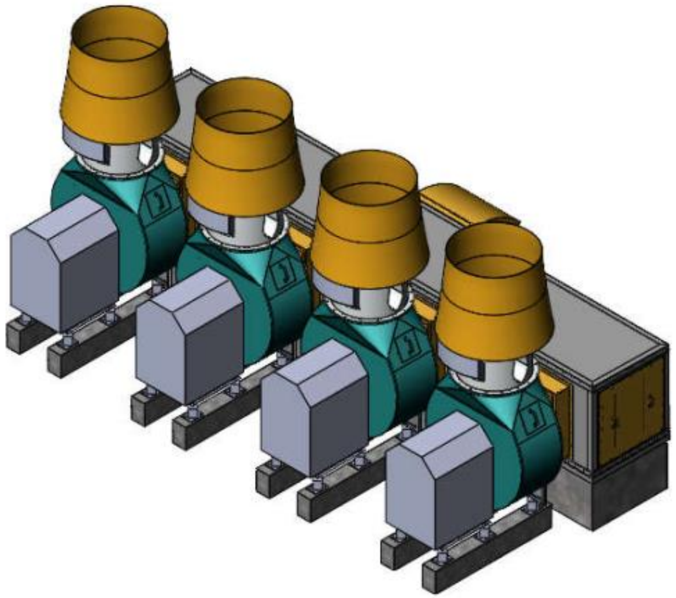
Utilizing the N -1 Configuration Concept

- 4 Fans operating in N -1 operation annual energy cost

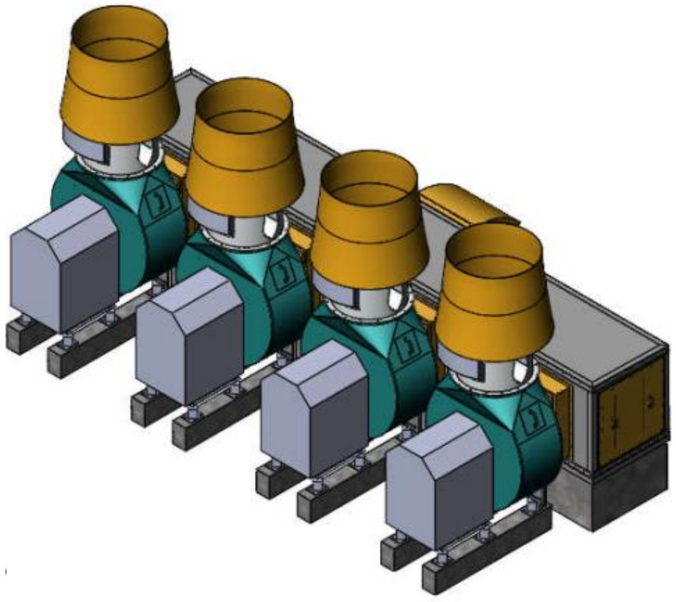
$0.10 / kW hr	Capacity Utilization	100%	90%	80%	70%	60%	50%			
	% time used	5%	10%	20%	40%	15%	10%	Concept		
Alternate/VFD controlled IFF (plume) fans/N-1	Mfg/Model									
M.K. Plastics Axijet 3000	Tag #									
Tag# LEF 1A,B,C,D	System CFM	60000	54000	48000	42000	36000	30000			
	SP ("wg)	4.5	4.5	4.5	4.5	4.5	4.5			
	Motor HP	40	40	40	40	40	40			
	# fans total	4	4	4	4	4	4			
	Connected HP	160	160	160	160	160	160			
	# fans running	4	4	4	3	3	2			
	CFM/fan	15000	13500	12000	14000	12000	15000			
	System bypass CFM	0	0	0	0	0	0			
	NV (fpm)	6173	5556	4938	5761	4938	6173			
	Fan RPM	1588	1501	1420	1529	1420	1588			
	BHP/fan	20.57	17.36	14.59	18.36	14.59	20.57			
	BHP/total	82.28	69.44	58.36	55.08	43.77	41.14			
	% time used	5%	10%	20%	20%	35%	10%	100%		
	Weighted BHP	4.11	6.94	11.67	11.02	15.32	4.11			**$34,657**



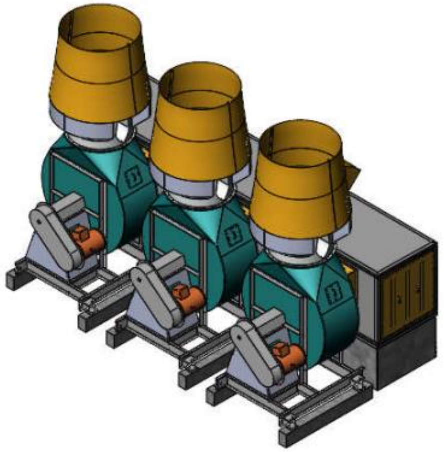
Utilizing the N -1 Configuration Concept

- 4 Fans operating in N -1 operational data

System statistics for N -1 Configuration																	
Operating Conditions							Motor					Package Information				Energy
Condition	Exhaust Volume (CFM)	Static Pressure (inch w.c.)	# Fans	# Fans operating	CFM/Fan	Fan Model	Fan dB(A) @ 10 Ft	BHP/Fan	Motor HP/Fan	Operating BHP	Connected Motor HP	Total Weight Fan, Motor and Plenum (lbs)	Width (Ft)	Length (Ft)	Footprint Fans and Plenum (SqFt)	Annual System Energy Cost ($0.10 /kW hr)
Normal	60,000	4.5	4	4	15,000	3000	55+6 = 61	20.57	40	82.28	160	6,910	13.5	24	324	$34,567
Emergency				3	20,000	3000	84+5 = 89	35.62	40	106.86	160					



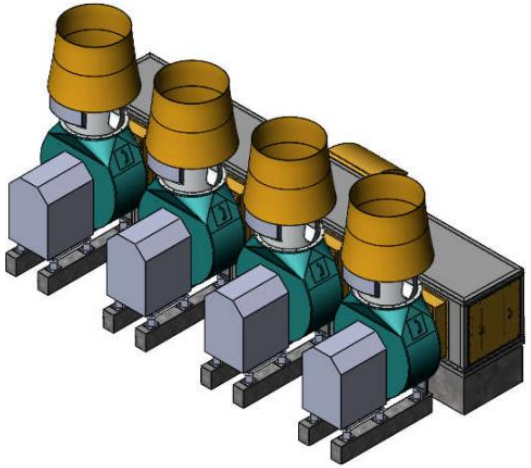
Comparing N+1 and N-1 Configuration



AxiJet 4450

	3 Fans operating N + 1	4 Fans operating N - 1
Weight (lbs)	3 x 3167+2273= **11,774**	4 x 1320+1630 = **6910**
Sound @ 100Ft dB(A)	54+3 = 57	55+6 = 61
Foot Print Area (Ft^2)	L= 25.4x W=17.2 = 436.9	L=24 x W= 13.5 = 324
Sound Pressure dB(A) @ 10ft	57	61
Annual System Energy Cost ($0.10/ kW Hr)	$31,371	$34,567

AxiJet 3000



Understanding N+1 and N-1 Configuration

Benefits associated with N-1 vs. N+1:

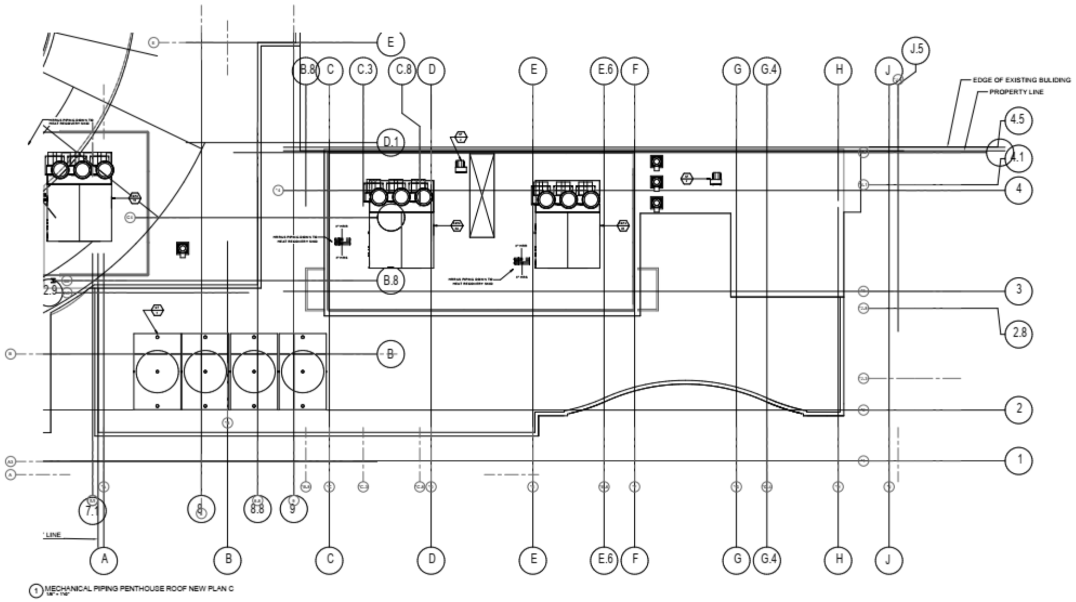
- Faster system response to fan failure
- Greater system stability / staging capability
- Comparable energy consumption/cost
- Better airflow/energy transfer over ERU coil and often ….
- Smaller system size (footprint)
- Reduced weight
- Lower first cost

Kristen Neath

Overview

- Introduction
- Understanding fan noise
- Sample outdoor noise ordinance
- Components of acoustical modeling of fan noise and environmental surroundings
- Sample analysis and silencer selection

Rooftop Fan Noise



- Noise is unwanted sound
- Sound is a propagating disturbance (a wave) in a fluid or solid
- Propagates from the equipment through the environment to adjacent properties
- Source, Path, and Receiver

Sound Source

- Most predominant noise source of any industrial or commercial air system
- Function of fan inlet, discharge, motor drive train and casing radiated noise
- Magnitude and intensity of noise will vary per …………..
- The rotating action of vanes produce a broad band sound spectrum consisting of low, mid to high frequencies

Fan Sound Power

- Type
- Size
- HP
- CFM
- Blade type & qty.
- Static pressure
- Rotational speed

Fan Noise

- A proper acoustic analysis begins with accurate FAN SOUND POWER LEVELS (dB), Lw, PWL

- It is important to obtain **discharge, intake** and **casing radiated** sound power levels per 8-octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1K Hz, 2K Hz, 4K Hz, 8K Hz

Acoustic Terminology

- **Sound Power Level** - the total acoustic energy output of a noise source independent of the environment

- **Sound Pressure Level** - dependent on environmental factors such as distance from the source, reflective surfaces, and other conditions of the room/building/ area hosting the source
  - Pressure the acoustical wave imparts on the receiver (Force/Area)
  - Dependent on the receiver’s location and environment (Area)

Acoustic Terminology

- Logarithmic addition of levels is non-linear:

Difference between levels to be combined, dB	0 to 1	2 to 4	5 to 9	10 and more
Number of dB to add to highest level	3	2	1	0

86 dB + 86 dB = 89 dB	86 dB + 78 dB = 87 dB
86 dB + 83 dB = 88 dB	86dB + 76 dB = 86 dB

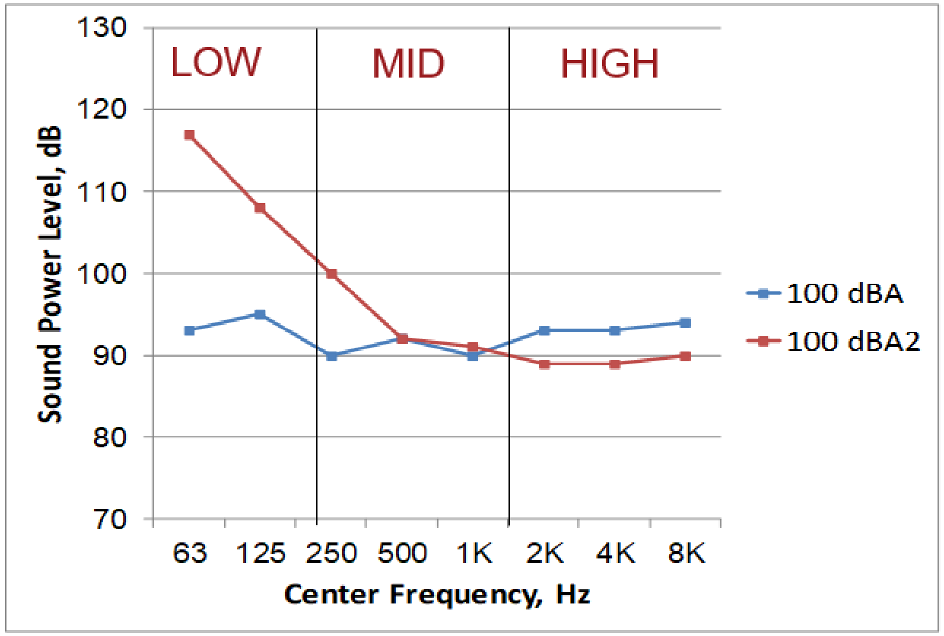
Acoustic Terminology

- Filters the spectrum to simulate the frequency response to sound by the human ear
  - Deemphasizes the low frequencies, compensating for the lower sensitivity of the human ear to low frequency
- Typically used for environmental/ outdoor noise design criteria

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	dBA
PWL	95	94	89	84	80	74	69	68	
A-Weighting filter	-26	-16	-9	-3	0	1	1	-1	
PWL A-weighted	69	78	80	81	80	75	70	67	**86**

Fan Noise

- The following **two sound spectrums** are **both 100 dBA**. But one has predominantly low frequency noise requiring an entirely different noise control solution than the other



Outdoor Noise Ordinance

Sample – Well Written Noise Ordinance

At Property Line:

Ambient noise quality zone	Day-time standards (7am - 10pm)	Night-time standards (10pm - 7am)
Noise quality zone N-1 (Low density residential RL; land-use zones R-1 to R-3	Leq=60 dB(A) measured for any one hour	Leq=50 dB(A) measured for any one hour
Noise quality zone N-2 (High density residential RH; land-use zones R-4 to R-10)	Leq=65 dB(A) measured for any one hour	Leq=55 dB(A) measured for any one hour
Noise quality zone N-3 (All Commercial and manufacturing land-use zones)	Leq=70 dB(A) measured for any one hour	Leq=70 dB(A) measured for any one hour

Outdoor Noise Ordinance

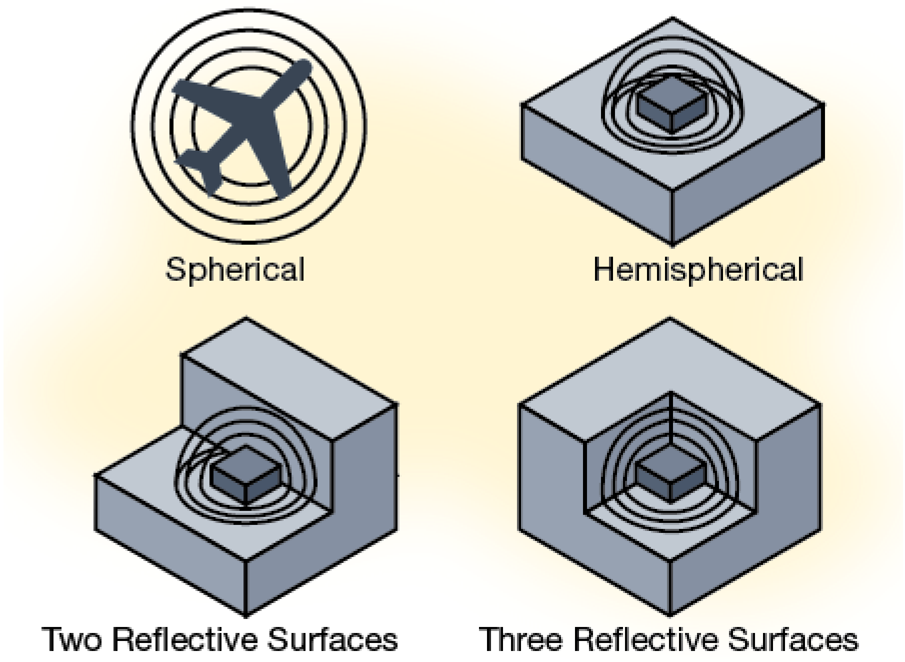
Common Sound	Noise / Sound Level
Rocket Launch Pad	180 dBA
Pile Driver	110 dBA
Garbage Truck	100 dBA
City Traffic	90 dBA
OSHA Permissible 8 hrs. Exposure	**85 dBA**
Noisy Restaurant	70 dBA
Conversational Speech	60 dBA
Light Auto Traffic at 100 ft.	55 dBA
Rural Ambient Noise Level	**45 dBA**
Library	30 dBA

Outdoor Noise Ordinance

- Ministry of the Environment NPC-300
- Municipal by-laws
- Owner may be forced to reduce noise levels or the owner may elect to take it upon themselves to reduce the noise levels
- Citations can consist of monetary fines or the shutting down a business until the sound level dictated by the noise ordinance is met

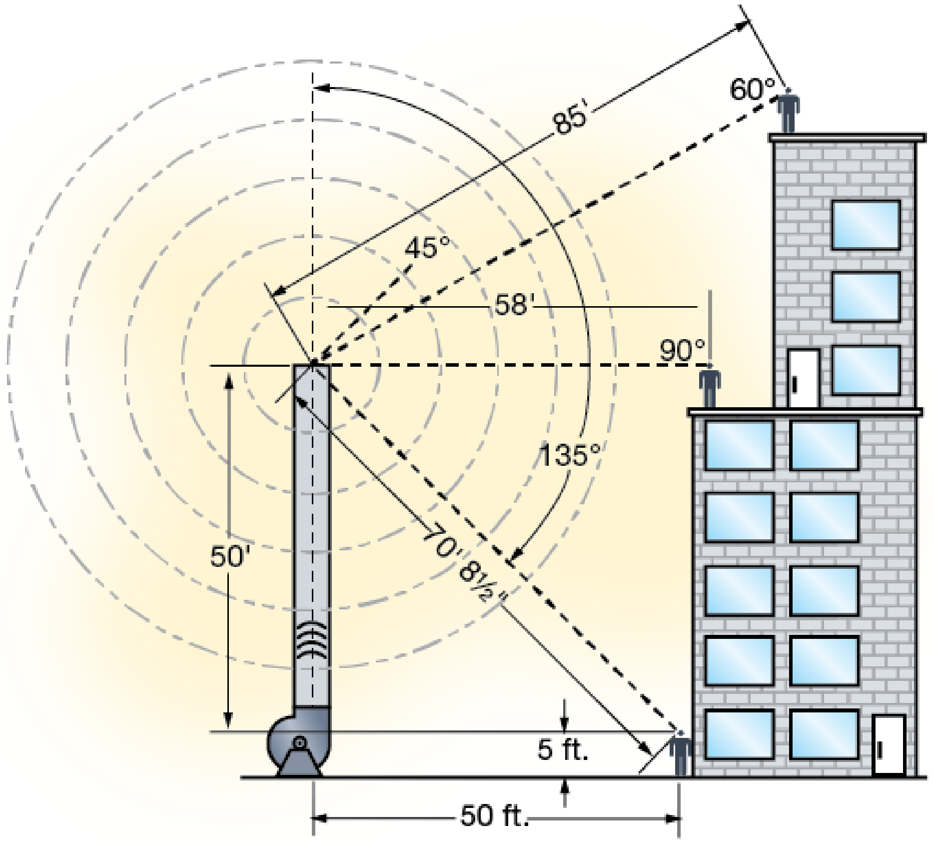
Sound Propagation

- Sound pressure reduction due to distance from source
- Sound propagation is affected by surrounding structures (i.e., buildings, alcoves, roof top surfaces, surrounding equipment)
- Nearby hard surfaces magnify noise
- Function of type and distance



Directivity

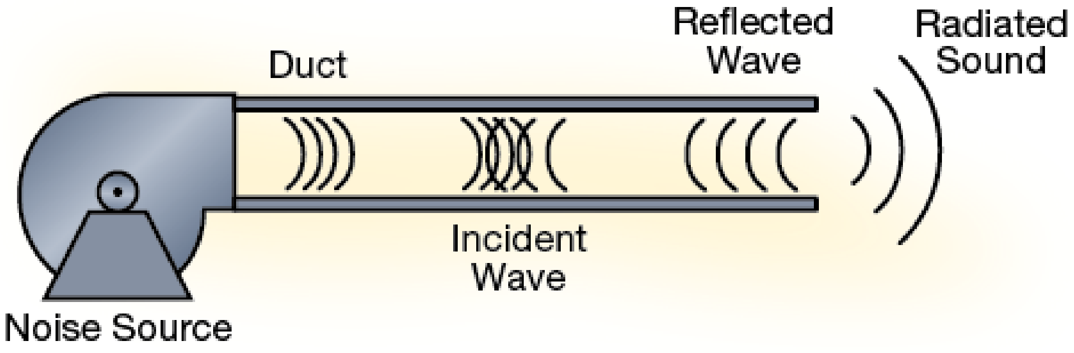
- Sound from a horizontal discharge duct or vertical discharge stack is more prominent in one direction
- Sound directly in front of an opening is louder than to the side
- Elevation between sound source and receiver is important



End Reflection

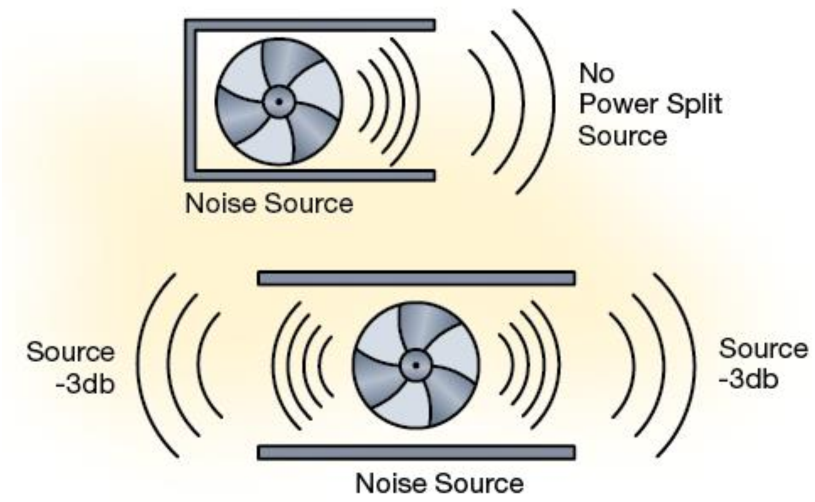
- Exhaust Fans are typically connected to either a horizontal discharge duct or vertical discharge stack

- Low frequency (most predominant) acoustic energy reflects back into the duct or discharge stack offering low frequency acoustic attenuation



Power Split

- If only total fan sound power levels are available intake and discharge power levels can be calculated assuming an equal power split



	Octave Band / Center Frequency, Hz								
	1	2	3	4	5	6	7	8	dBA
	63	125	250	500	1K	2K	4K	8K	
TFLw, dB	108	105	100	95	86	81	78	73	96
Adj., dB	-3	-3	-3	-3	-3	-3	-3	-3	
Inlet Lw, dB	105	102	97	92	83	78	75	70	93
outlet Lw, dB	105	102	97	92	83	78	75	70	93

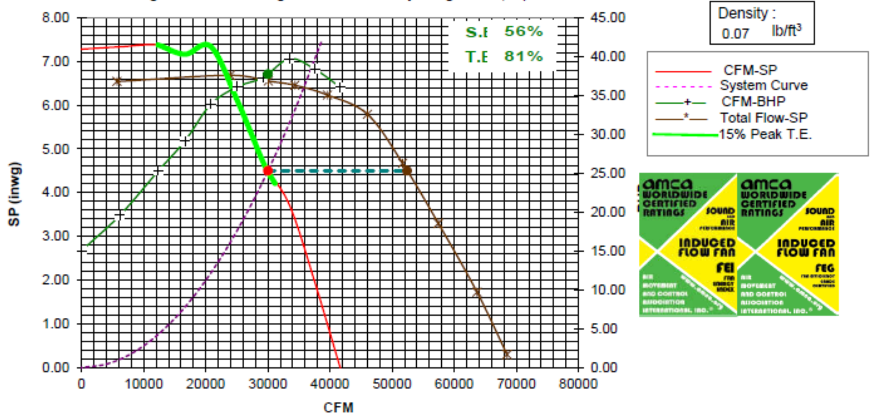
Lab Exhaust Fan - Discharge

Date	.		Model			10 [mph]
			Fan Size	4450	EH =	61.4 [feet]
Sys. No.	LEF - 1A;1B;1C		Dia.[in]	44.50	PH =	45.1 [feet]
	3 Fan N+1 Operation		CFM	30000	NV =	5597 [fpm]
	60,000 CFM System Flow		SP	4.5	WV =	2625 [fpm]
Drawing	.	A — FEI_T Based on	BHP	37.75	TF =	52390 [cfm]
Revision	.	Default Motor Efficiencies ☑	RPM	999	TS =	11638 [fpm]
		Regulated Motor Efficiencies ☐			T =	70 [°F]
					ALT =	0 [feet]

CLASS II WHEEL

Air performance — $FEI_T = 1.30$

TF=Total Flow; NV=Nozzle Velocity; WV=Windband Velocity; TS=Tip Speed
EH: Effective Plume Height. (Plume Height + Fan Height)
Plume Height is calculated using ASHRAE Laboratory Design Guide, Equation 9-2



Performance shown is for installation type C: Ducted inlet, Free outlet. Power rating (BHP) does not include transmission losses. Performance ratings do not include the effects of appurtenances (accessories). Performance ratings do not include the effects of crosswinds. FEI values are calculated in accordance with AMCA 208 and are based on default motor efficiencies. FEI values for fans with specific motors will vary slightly from those shown.

Sound power level — The sound power level ratings shown are in decibels, referred to 10^{-12} Watts calculated per AMCA standard 301. Values shown are for (outlet Lwo and LwoA) sound power levels for installation type C: Ducted inlet, Free outlet. Ratings do not include the effects of duct end correction. The A-weighted sound ratings have been calculated per AMCA Standard 301.

RPM	Hz 63	125	250	500	1000	2000	4000	8000	LwA
999	95	96	91	88	93	94	87	77	98

- Two fans running at any time, 1 standby
- 30,000 CFM per fan
- 49” Diameter connection
- Sound power levels: 95/96/91/88/93/94/87/77
- Property Line 10’ from fan
- Noise Ordinance 50 dBA

Factors to Consider

- Equipment Manufacture's Warranty & Installation Guidelines
- Local Codes (i.e., electric, etc.)
- Proper Equipment Ventilation
- Local Noise Ordinance
- Location of Equipment
- Equipment Dimensions
- Maintenance Access
- Structural Supports (i.e., snow, wind and seismic loads, etc.)

Acoustic Analysis - Example

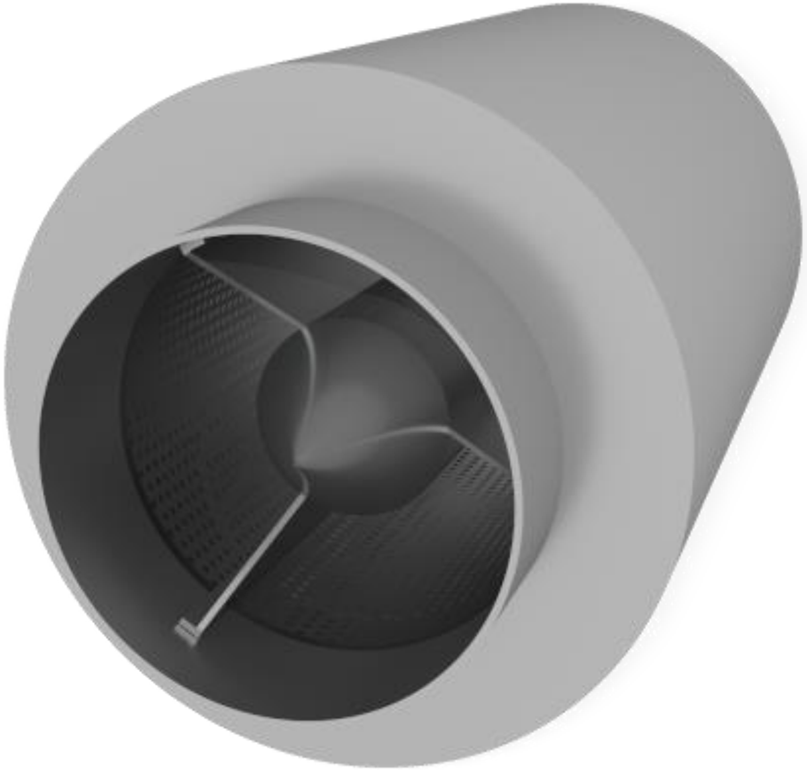
Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	dB(A)
FAN PWL Flow Volume 30000 CFM	95	96	91	88	93	94	87	77	**98**
POWER SPLIT Fan Discharge	-3	-3	-3	-3	-3	-3	-3	-3	
END REFELECTION Diameter = 1m, Q=1	-5	-2	-1	0	0	0	0	0	
DIRECTIVITY Diameter = 1m, 90°	-2	-3	-5	-8	-12	-16	-17	-17	
DIVERGENCE Distance = 10', Q = 1	-21	-21	-21	-21	-21	-21	-21	-21	
SPL at 10 FT, W/O SILENCER	64	67	61	56	57	54	46	36	**62**

Silencer Selection

- Circular Silencer
- Insertion Loss:

63	125	250	500	1000	2000	4000	8000
2	8	14	26	38	12	9	3

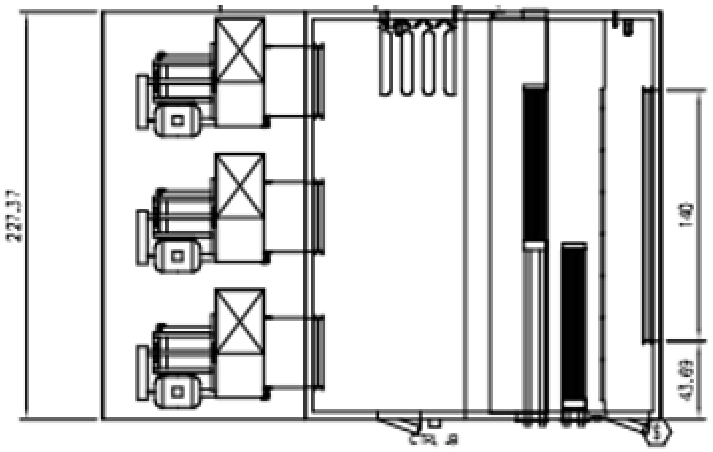
- Pressure Drop: 0.14” w.g.
- Stainless steel construction
- Inlet/outlet connection flanges, predrilled
- Fiberglass cloth media covering



Acoustic Analysis - Example

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	dB(A)
FAN PWL Flow Volume 30000 CFM	95	96	91	88	93	94	87	77	**98**
POWER SPLIT Fan Discharge	-3	-3	-3	-3	-3	-3	-3	-3	
END REFELECTION Diameter = 1m, Q=1	-5	-2	-1	0	0	0	0	0	
DIRECTIVITY Diameter = 1m, 90°	-2	-3	-5	-8	-12	-16	-17	-17	
DIVERGENCE Distance = 10', Q = 1	-21	-21	-21	-21	-21	-21	-21	-21	
SPL at 10 FT, W/O SILENCER	64	67	61	56	57	54	46	36	**62**
SILENCER LEF Discharge ATTENUATION	2	8	14	26	38	12	9	3	
SPL at 10 FT, W/ SILENCER	62	59	47	30	19	42	37	33	**48**

Lab Exhaust Fan - Damper



- Two fans running at any time, 1 standby
- 30,000 CFM per fan
- 50.625” x 50.625” connection
- Sound power levels: 95/96/91/88/93/94/87/77
- Property Line 10’ from fan
- Noise Ordinance 50 dBA

Acoustic Analysis - Example

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000	dB(A)
FAN #1 PWL Flow Volume 30000 CFM	95	96	91	88	93	94	87	77	**98**
POWER SPLIT Fan Discharge	-3	-3	-3	-3	-3	-3	-3	-3	
FAN #1 PWL	92	93	88	85	90	91	84	74	**95**
FAN #2 PWL Flow Volume 30000 CFM	95	96	91	88	93	94	87	77	**98**
POWER SPLIT Fan Discharge	-3	-3	-3	-3	-3	-3	-3	-3	
FAN #2 PWL	92	93	88	85	90	91	84	74	**95**
FAN PWL IN PLENUM	95	96	91	88	93	94	87	77	**98**

Acoustic Analysis - Example

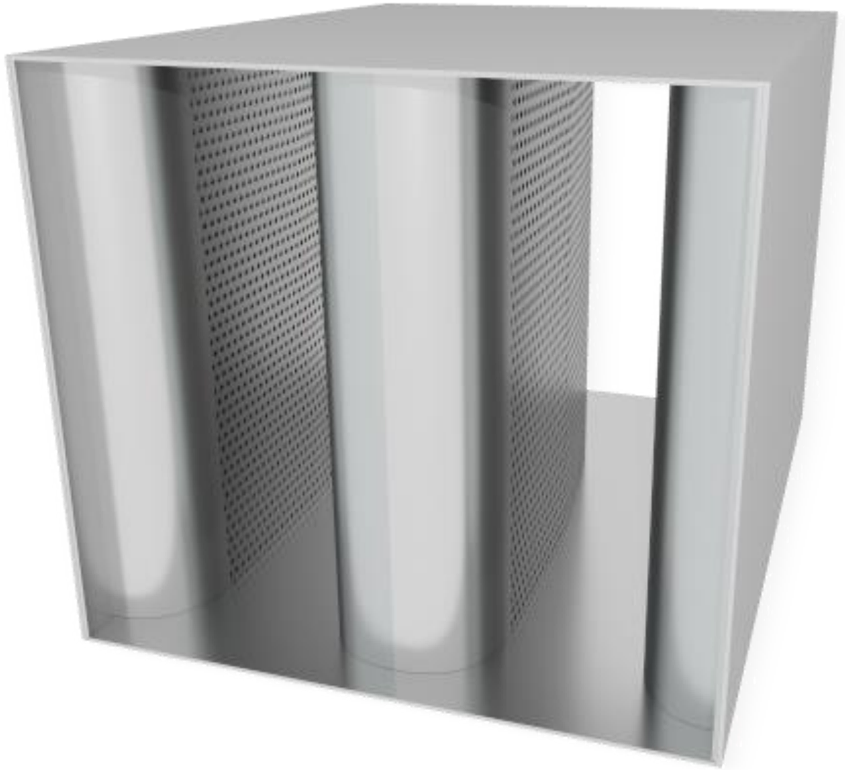
FAN PWL IN PLENUM	95	96	91	88	93	94	87	77	**98**
ELBOW EFFECT	-8	-4	-3	-3	-3	-3	-3	-3	
END REFEFLECTION Diameter = 50.625m, Q=2	-3	-1	0	0	0	0	0	0	
DIRECTIVITY Diameter = 1m, 90°	-2	-3	-5	-8	-12	-16	-17	-17	
DIVERGENCE Distance = 10', Q = 1	-21	-21	-21	-21	-21	-21	-21	-21	
SPL at 10 FT, W/O SILENCER	61	67	62	56	57	54	46	36	**62**

Silencer Selection

- Rectangular Silencer
- Insertion Loss:

63	125	250	500	1000	2000	4000	8000
2	7	13	19	18	13	8	6

- Pressure Drop: 0.06” w.g. @ 750 fpm
- Galvanized steel construction
- Slip connections
- Fiberglass media



Acoustic Analysis - Example

FAN PWL IN PLENUM	95	96	91	88	93	94	87	77	**98**
ELBOW EFFECT	-8	-4	-3	-3	-3	-3	-3	-3	
END REFELECTION Diameter = 50.625m, Q=2	-3	-1	0	0	0	0	0	0	
DIRECTIVITY Diameter = 1m, 90°	-2	-3	-5	-8	-12	-16	-17	-17	
DIVERGENCE Distance = 10', Q = 1	-21	-21	-21	-21	-21	-21	-21	-21	
SPL at 10 FT, W/O SILENCER	61	67	62	56	57	54	46	36	**62**
SILENCER LEF Discharge ATTENUATION	2	7	13	19	18	13	8	6	
SPL at 10 FT, W/ SILENCER	59	60	49	37	39	41	38	30	**49**

Resources

- **AMCA International**: *www.amca.org*
- **AMCA Publication 1011-03 (R2010)** (Free PDF Download): *www.amca.org/store*
  - > Certified Ratings Program- Product Rating Manual for Acoustical Duct Silencers
- **2014 AMCA *inmotion* Magazine:** *https://www.amca.org/educate/inmotion/amca-inmotion-magazine-2014-issue.html*
  - **>** Controlling Outdoor Fan Noise – Items to Consider

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- Presenters:
  - Charlie Meyers, Certified Ratings Program Manger, AMCA
  - Nabil Shahin, International Technical Director, AHRI-MENA

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