Air Injection Vacuum Blower Noise Control

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Abstract

Air injection vacuum blowers are a widely used series of blower utilized in applications with the need of high vacuum levels, over 15” Hg. These high pressure blowers can be utilized in applications including: wet and/or dry waste removal (industrial, municipalities, etc.); central vacuum systems; aeration systems; and pneumatic conveyors. Air injection blowers are a lobe rotary configuration that produce high vacuum pressures using atmospheric air injection to the blower itself to reduce overheating of the gas medium and power absorbed by the blower. A significant complaint related to the use of high flow blowers is the noise. This paper details an investigation to:

1. Analyze, define, and quantify the problematic noise
2. Engineer, design, and quantify noise control performance and effect of the noise control to reduce the overall noise
3. Manufacture prototype noise control equipment
4. Install and conduct post-installation performance and noise measurements to validate the noise control equipment and reduced blower noise compared with the predicted performance

Blower Applications

Air injection vacuum blowers are a widely used series of blower utilized in applications with the need of high vacuum level, over 15” Hg. These high pressure blowers can be utilized[1] in applications including: wet and/or dry waste removal (industrial, municipalities, etc.); central vacuum systems; aeration systems; and pneumatic conveyors. Air injection blowers are a lobe rotary configuration that produce high vacuum pressures through using atmospheric air injection to the blower itself to reduce overheating of the gas medium and power absorbed by the blower. A significant complaint related to the use of these blowers is the noise.

Study Objective

Noise Solutions Inc. conducted a Noise Impact Assessment (NIA) on an air injection vacuum blower unit to identify the prevalent noise sources, as well as design custom noise abatement equipment to reduce the amount of airborne noise from the machine during operation. The reason for conducting this study was to investigate, and reduce, concern over occupational health of operators utilizing these blowers, and lessen the degree of residential/pedestrian disturbance during blower operation in urban areas.

Identification of Problematic Noise

Air injection vacuum blowers often utilize diesel engines to rotate the internal 3 lobe assembly, and their respective accessories, creating many noise sources. Prevalent sources with high sound power intensity include the: driving engine casing, engine exhaust, blower exhaust, blower air injection inlet, oil cooler fan, blower casing & manifolds, as well as the blowers air filter & respective piping. Being that this style of blower is generally used in confined spaces many of the noise sources are in close proximity to one another. This proximity causes a challenge discerning the relative contribution of the many individual noise sources to the total noise signature as there is cross contamination between the individual sound fields of each source.

Analysis and Quantification of Identified Noise Sources

A Brüel & Kjær 2260 Investigator sound level meter was used to accurately quantify the noise produced by the sources deemed significant in the NIA, which were: the blower casing; the blower exhaust outlet; and the blower air injection inlet. These noise sources were found to be extremely dominant during the blowers operation, and were made the primary objectives of the investigation.

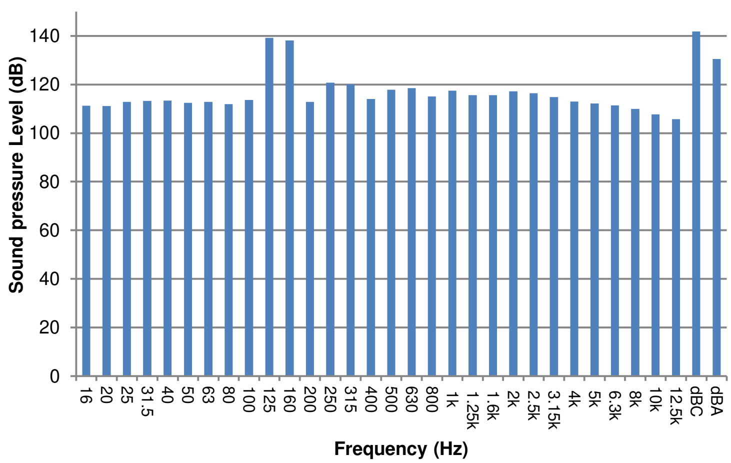
The measured sound pressure levels produced by the three sources stated above are presented in Table 1.

Table 1. Order Ranked Sound Pressure Levels
No Blower Silencers

Source	Sound Level Contribution	
	dBC	dBA
Blower Air Injection Inlet	150.6	130.6
Blower Exhaust	150.5	130.5
Blower Casing	133.9	113.9
Sum	153.6	133.6

A tone centered around 142.5 Hz can be seen in Figure 1.

Figure 1. Air Injection Vacuum Blower Exhaust Sound Pressure Levels



Noise Abatement Equipment Design

A priority in the design of custom noise abatement equipment for this application was to reduce the tone while staying within the design constraints.

Design Constraints

Being that this style of blower can be used in both mobile and stationary applications, many design constraints are dealing with size and weight restrictions. Each blower unit requires separate silencer bodies for the air injection inlet and exhaust, due to flow pulsations and airflow direction. In this study the blower was mounted on a mobile unit, so each silencer could be no larger than 24” in diameter, nor over 92” long. It was also stated as a design requirement that each silencer body had to weigh less than 600 lbs. Weight restrictions existed for mounting reasons, as well as mobile unit balancing.

Other design constraints included back pressure allowances, as well as sizing the silencer expansion chambers to specifically attenuate the tone at 142.5 Hz. This blower required that the backpressure added from a silencer and attached piping would not surpass 12" H_2O, so this had to be taken into account when designing the silencer internals.

Engineering

By using equations that describe the sound attenuation of a reactive expansion chamber, the tone at 142.5 Hz was specifically targeted and the sizes of expansion chambers were designed accordingly. Additional reactive and absorptive noise attenuating components were designed to reduce the entire frequency range in addition to only attenuating the tone.

Due to the fact that the sound level intensity is so high coming from the blower exhaust and air injection inlet, it was realized that not only the silencer outlet/inlet have a high level of sound emissions, but the shell of the silencer itself would radiate substantial noise. In order to eliminate this shell radiated noise, combination internal acoustically absorptive and internal acoustical lagging was incorporated into the design.

In conjunction with the acoustic design of the silencers, Computational Fluid Dynamics (CFD) analyses were conducted to optimize silencer backpressure in relation to acoustic performance. The optimum analysis estimated a maximum backpressure of 11.7" H_2O under blower full load conditions.

Post-Install Evaluation

A set of 2 prototype silencers were constructed by Noise Solutions Manufacturing, and installed, along with a set of acoustic blankets to lag the blower casing on a blower for testing and determine equipment performance evaluation. Once the blower casing/manifolds were lagged with the acoustic blankets and the silencers were installed; noise, backpressure, and blower operation measurements were completed.

To ensure safe operation of the blower, backpressure measurements were conducted prior to any noise readings. A manometer was used to measure that under blower full load conditions the exhaust silencer had a maximum backpressure of 11.2" H_2O.

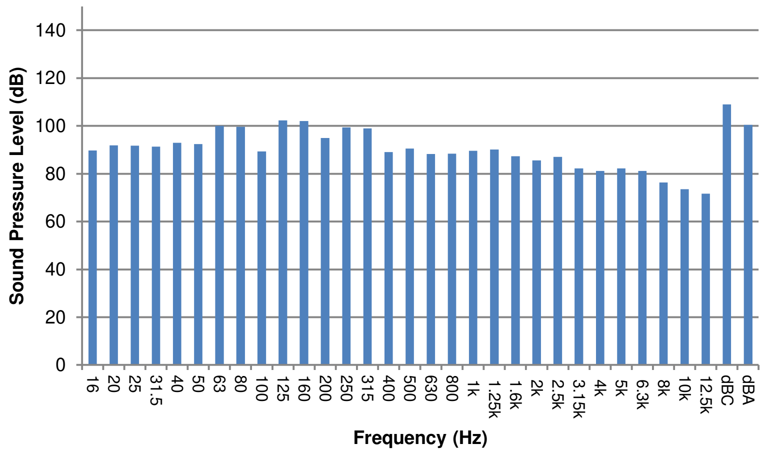
Post-install noise readings were taken and are presented in Table 2.

Table 2. Order Ranked Sound Pressure Levels
with Noise Solutions Blower Silencers and Blankets

Source	Sound Level Contribution	
	dBC	dBA
Blower Casing	106.3	103.0
Blower Exhaust	109.0	100.4
Blower Air Injection Inlet	105.7	98.0
Sum	112.0	105.7

It can be seen in Figure 2 that the 142.5 Hz was significantly reduced and effectively eliminated. This resulted in the level of the noise as well as the annoyance of the blower noise signature being greatly reduced.

Figure 2. Air Injection Vacuum Blower Exhaust with Noise Solutions Silencer



The installation of the custom noise abatement equipment resulted in a total reduction in sound pressure levels of approximately 27.9 dBA and 41.6 dBC.

References

[1] Robuschi. *Common blower applications*. Retrieved July 30, 2010, from http://www.robuschi.com/rbdv.asp