

Noise	Abnormal Sound That Occurred on High-Powered Suction Truck	Other Equipment
Resonance		

Object Machine	Suction procedure of a high-powered suction truck (Fig.1) is shown in Fig.3.	
Observed Phenomena	During a test operation of a high-powered suction truck, very large, abnormal sounds with a single frequency (150Hz) generated that were different from stationary sounds generated by an engine or a vacuum pump (Roots-type blower).	
Cause Estimation	As it is thought that noise from a suction truck are influenced to a great extent by noises generated at the last outlet port (indicated by ○) of the piping system as shown in Fig.3, a silencer is installed on the Roots-type blower downstream side in many instances. Considering the loud noises from the last outlet port, measurement of noises at the last outlet port and frequency analysis were conducted, with the results shown in Fig.2. Judging from a dominant frequency component, it was determined that a resonance occurred at the constituent equipment located on the downstream of the Roots-type blower.	
Analysis and Data Processing	<p>As shown in Fig.4, a microphone was installed at a position 150mm away in the horizontal direction from the center of the last outlet port, and also 60mm above in the vertical direction from the last outlet port, to perform measurement. The blower pulsation frequency <math>f</math> (Hz) appearing as the dominant frequency component of this equipment is given as <math>f = nZN/60</math>, where <math>n</math> = number of rotor blades of the root blower, <math>Z</math> = number of rotors, <math>N</math> (rpm) = rotational speed.</p> <p>In case of this blower, <math>Z = 2</math>, <math>n = 3</math>, so</p> $f = \frac{N}{10} \quad (1)$ <p>Rotational speed of the Roots-type blower at the time of measurement was set at 1,500rpm, that is fundamentally the rated rotational speed. In this case, the Roots-type blower pulsation frequency is 150Hz from Equation (1) above. Since this frequency is equal to the dominant frequency of the above-mentioned last outlet port noise, the root blower is the sound source. Measurements were made while this rotational speed was changed from 1,250rpm (minimum operational rotational speed) to 1,750rpm (maximum allowable operational rotational speed) in every 50rpm step. Thus, verification was made of the presence or absence of resonance from the relationship between the magnitude of the Roots-type blower pulsation frequency components and the root blower pulsation frequency <math>f</math>, with the results given in Fig.5. From this figure, a resonance at 160Hz was identified.</p>	
Countermeasures and Results	A trial and error process was carried out for retrieval of resonance positions and for determining countermeasures. As a result, an inner silencer (outer diameter 165mm, colored part) was mounted at the last outlet port/cooling water catcher (length: 570mm, inner diameter: 400mm, discharge port diameter: 165mm) under the condition of resonance as shown in Fig.4, then noise levels were measured by changing the insertion length $L_i$ , with the results given in Fig.6. This figure shows that for $L_i = 470$ mm, the noise level of 160Hz component decreased by as much as 27.1dB (A). Fig.7 shows sound pressure distributions at the last outlet port inside for the inner silencer insertion length $L_i$ being 0mm, 370mm, 470mm, and 520mm, respectively. For $L_i = 0$ mm to 370mm, half-wavelength resonance mode appeared, but at $L_i = 470$ mm, the sound pressure distribution clearly changed to another mode, with the outlet port pressure decreased. This is because the insertion modified the boundary conditions. It was thus concluded that, at a certain length of the inner silencer, the insertion tube acts as a main tube and the last exhaust cylinder as a resonance body at a part marked by a red circle in Fig.7, a resonance type silencer formed, which was the cause of this noise reduction.	
Lesson	As a method for searching a resonance position, some of change are applied to boundary positions (open end and close end). A resonance position may be identified by moving the resonance frequency and confirming an abrupt reduction in the sound pressure level.	
References	(1) Kunihiro Ishihara, et.al., "Study on Noise Reduction of High-Powered Suction Truck", AISSA, Vol.4, (2015)	
Keywords	Resonance, high-powered suction truck, inner silencer, BEM, resonant type silencer	



Fig.1 High-powered suction truck

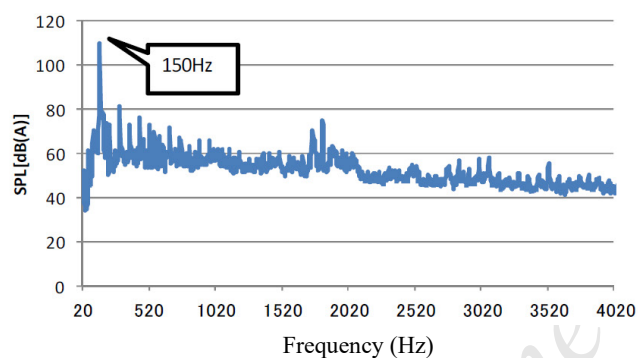


Fig.2 FFT analysis result

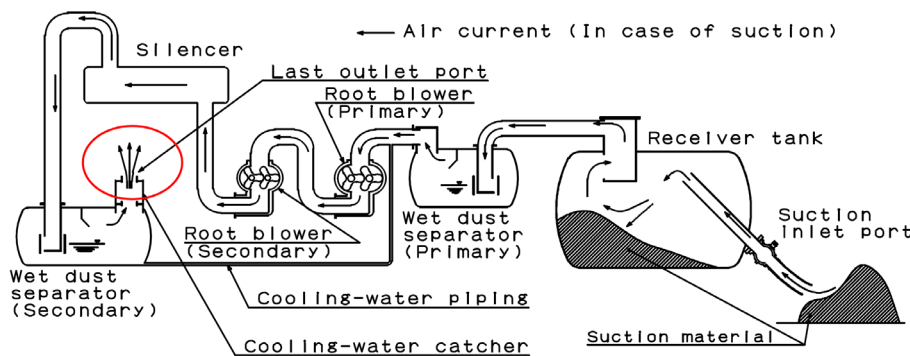


Fig.3 Suction procedure

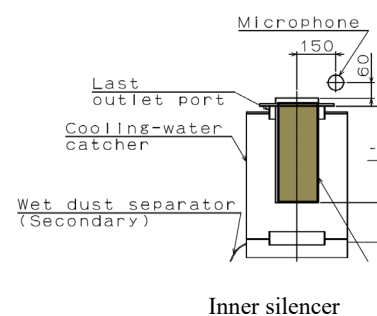


Fig.4 Condition wherein an inner silencer is inserted into a cooling water catcher

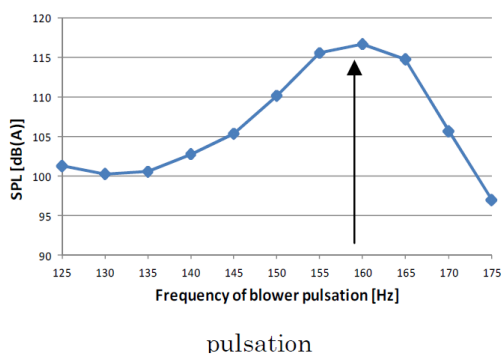


Fig.5 Rotational speed and noise level

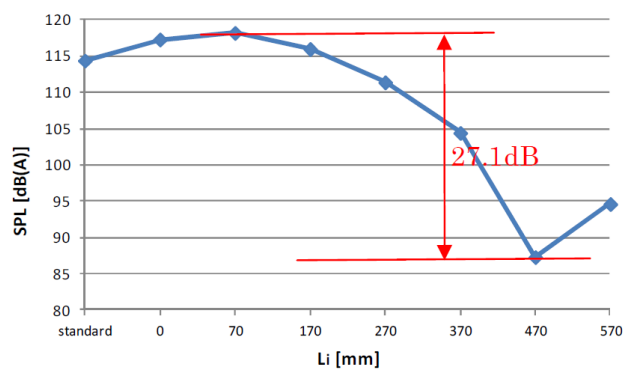


Fig.6 Relationship between insertion length and sound pressure level

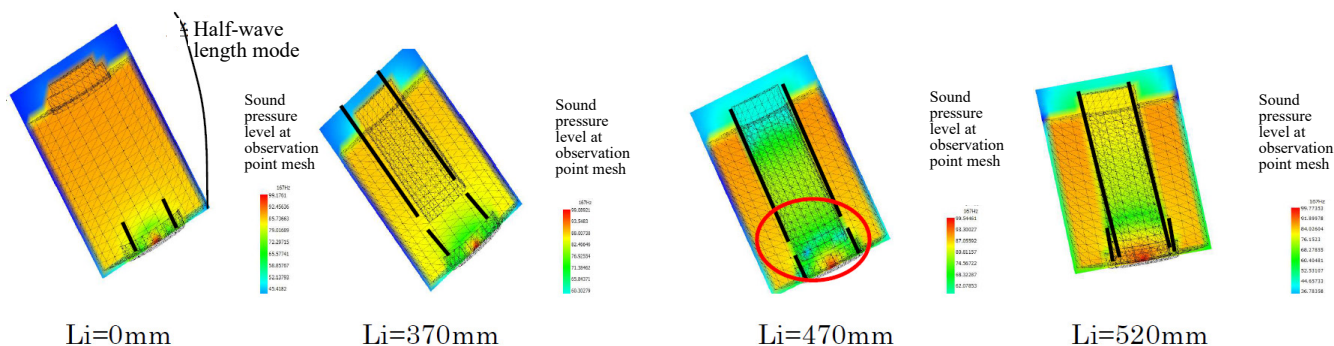


Fig.7 Sound pressure distribution with an inner silencer inserted at the last outlet port