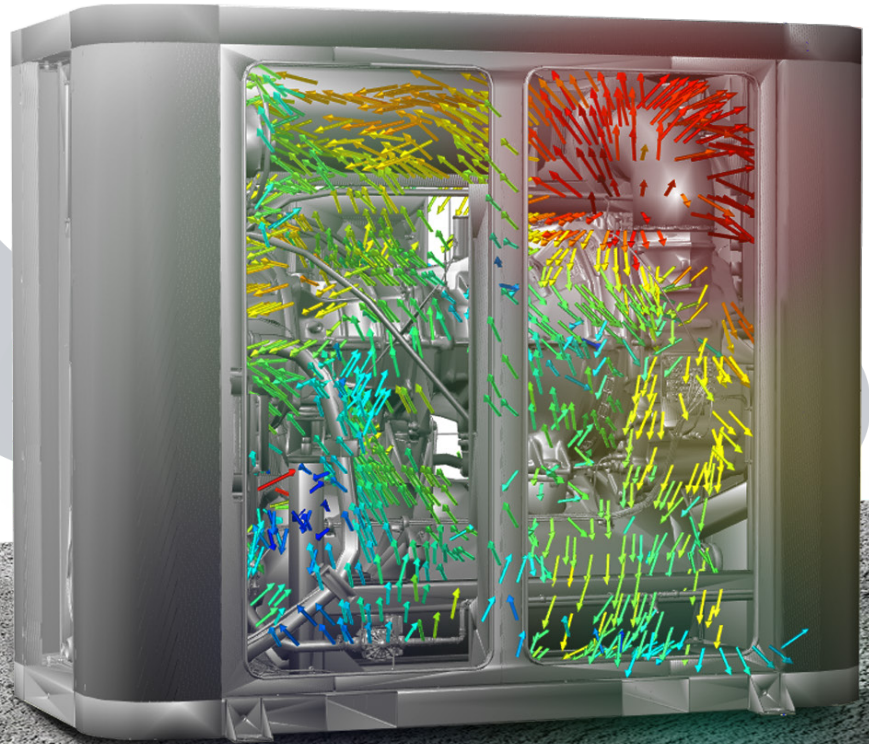


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Case study

REDUCING NOISE EMISSIONS FROM LONTRA'S LP2 COMPRESSOR

Using Microflow Scan&Paint 3D



INTRODUCTION

Lontra has a culture of innovation, encouraging thorough engineering evaluation to design better products. We wanted a rigorous approach to identify and precisely target key noise sources in our new blower, to efficiently achieve a quiet product. LP2 is the first fully packaged blower manufactured by Lontra using its proven patented Blade Compressor. It operates at up to 1barG, delivering up to 2600m³/h of air at 2500rpm. It is a positive displacement machine, which produces 1 discharge per revolution, resulting in low frequencies of emitted noise. This poses some unique acoustic challenges for various aspects of the design, and led us to use the Microflown equipment. Microflown Scan&Paint 3D utilises sensor technology that directly measures acoustic particle velocity and sound intensity in 3D. A 3D model of the compressor and enclosure is imported into the software where the sound field can be visualised and quantified. The tool allows us to identify sources within the enclosure, prioritise and precisely target them with minimal modifications and cost. The key benefit from Lontra's perspective is the ability to accurately resolve low frequencies, even below 50Hz, which is critical due to the low running speeds of the LP2. Additionally, with the same equipment we could calculate sound power even when used in relatively small test cells, which is important to avoid costly facilities.

GOAL & REQUIREMENTS

Reducing noise emissions, especially the low frequency components, from Lontra's LP2 compressor.

- Quickly identify dominant noise areas
- Measure in-situ, in a normal environment
- Measure low frequencies, even below 50Hz
- Reducing the overall sound power level

MEASUREMENT METHODOLOGY

A pre-production LP2 unit was scanned using Microflown Scan&Paint 3D to locate where the sound was emitted from the enclosure (scanning the outside), and to then identify the sources responsible for those emissions inside the enclosure (scanning the interior of the opened enclosure). Due to the size of the LP2 package, the outside of the enclosure required around 16 individual trajectories, by repositioning the 3D camera. All the trajectories were analysed together in the Velo software, giving a single processed dataset.



A 3D model is used as a visual reference as well as to automatically position the 3D tracker into the measuring environment.

The acoustic data acquisition process starts by manually moving a 3D sound intensity probe whilst a stereo camera is used to extract the instantaneous position of the sensor in the 3D space. The recorded signals are split into multiple segments and assigned to their corresponding locations using a spatial discretization algorithm. The spatial resolution is defined during the post-processing stage and thus can be adjusted depending on the available data. The maximum feasible resolution is determined by the accuracy of the 3D tracker, in this case, down to 3 millimeters. Sound pressure, particle velocity, or sound intensity across the sound field can then be computed to provide a visual representation of the sound distribution.



OUTCOME OF THE MEASUREMENT CAMPAIGN

The results were used to inform design changes, which were implemented into a subsequent enclosure:

- Redesigned inlet silencer to better attenuate the fundamental tone, and hence reduce excitation of the rear panel
- Softer anti-vibration mounts to reduce vibration transmission between front and rear panels
- Stiffening of front and rear panels
- Improved outlet pipe cover
- Better quality control for enclosure panel assembly

The improved enclosure was then scanned again, and the results were compared to quantify the improvement.



When first identifying regions of interest, we use broad frequency ranges, such as shown in Figure 1. Here they show the effect of improving the design of the cover over the compressor outlet pipe, which was previously rattling, causing emissions over a wide frequency range. This change helped contribute to a greatly reduced A-weighted emission from the rear of the enclosure.

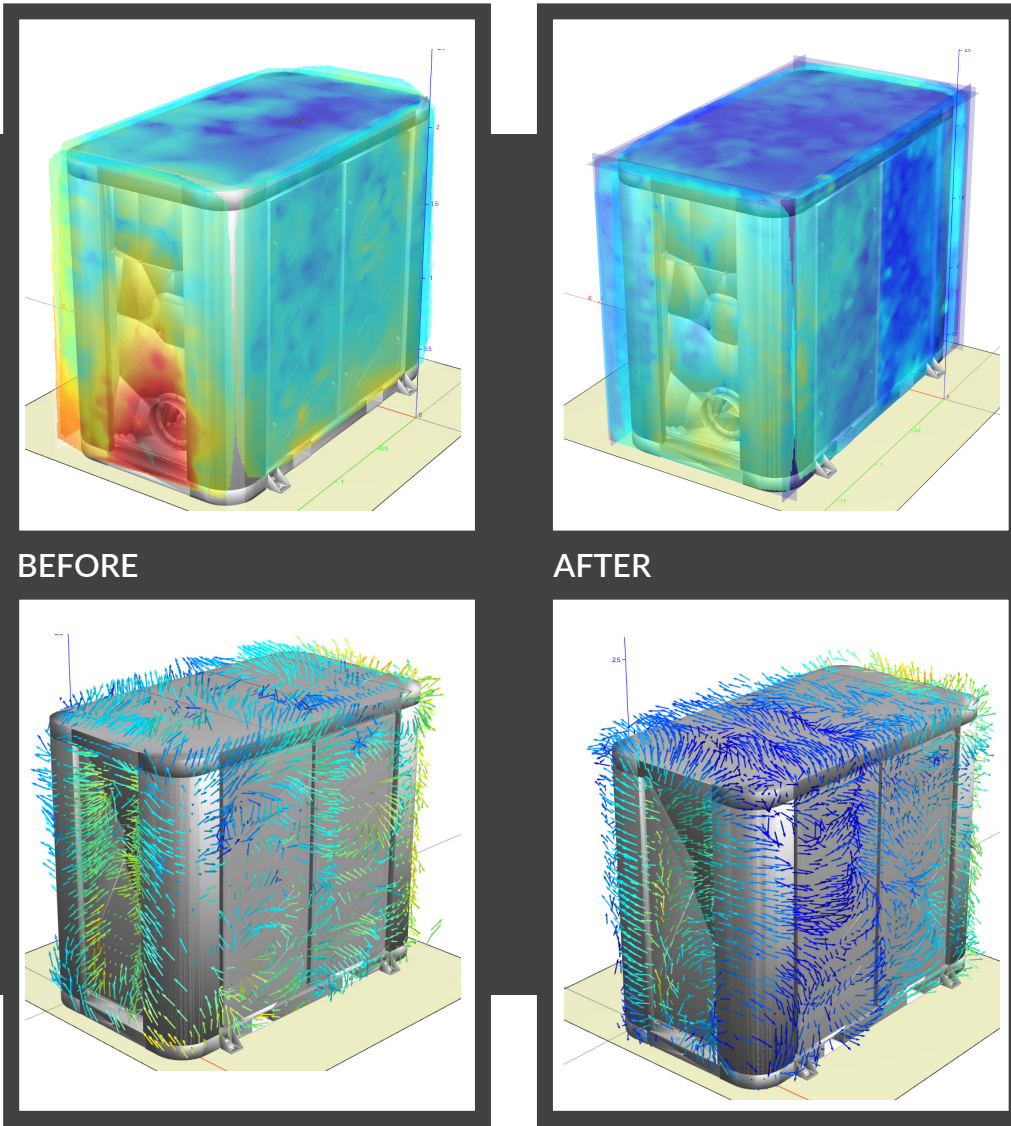


Figure 1: Comparison of magnitudes of active intensity for 180-2840Hz, plotted using planes defined on each side of the enclosure

Figure 2: Comparison of active intensity vectors for 24-200Hz, covering the first 4 tones

Figure 2 shows reduced emissions from the front of the enclosure, as well as reduced emissions from all surrounding panels. The scans allowed us to conclude that the front panel was not itself a source, but primarily an emitter of vibration transmitted to it from the rear panel by the inlet silencer, which acted as a bridge between them. By using much softer anti-vibration mounts for the inlet silencer, the transmitted vibration was reduced, and emitted noise from the front (especially at low frequencies) was greatly reduced, as seen in Table 1 on the next page.

	Before		After	
	Sound Power level (dB ref 1e-12W)	A-weighted Sound power level (dB ref 1e-12W)	Sound Power level (dB ref 1e-12W)	A-weighted Sound power level (dB ref 1e-12W)
Top	105.7	84.0	103.6	79.1
Front	110.7	90.3	102.6	90.8
Electrical side	108.0	89.2	105.0	84.1
Rear	117.9	93.5	115.7	87.1
Service side	107.8	87.7	105.8	84.1
Total	119.5	96.9	116.8	93.6

Table 1: Comparison of emissions from enclosure before and after the improvements. Greatest changes are highlighted.

Unweighted emission was reduced by 2.7dB. Although by far the greatest emitter is still the rear of the enclosure (the ambient air intake is the greatest source of pulsation at the running speed), the front of the enclosure is now the lowest emitter, having been vibrationally isolated from the rear.

Total A-weighted sound power emission from the enclosure was reduced by 3.3dB, which was helped by a 6.4dB reduction in emission from the rear of the enclosure (rattling outlet pipe cover). The greatest source of A-weighted emission is now the front of the enclosure, where the noise exits via the large cooling vents. During the next phase of improvements, the internal sources contributing to this will be addressed, and the vents themselves will be optimized.

Although it was originally thought that the greatest source of fundamental pulsation would be from the aircend inside the enclosure, this data shows that the source is in fact the inlet silencer atmospheric air intake, and the noise enters the enclosure interior only through the cooling fan located next to the intake. This meant that the best way to reduce excitation at the fundamental frequency was by redesigning the inlet silencer to better attenuate around 42Hz.

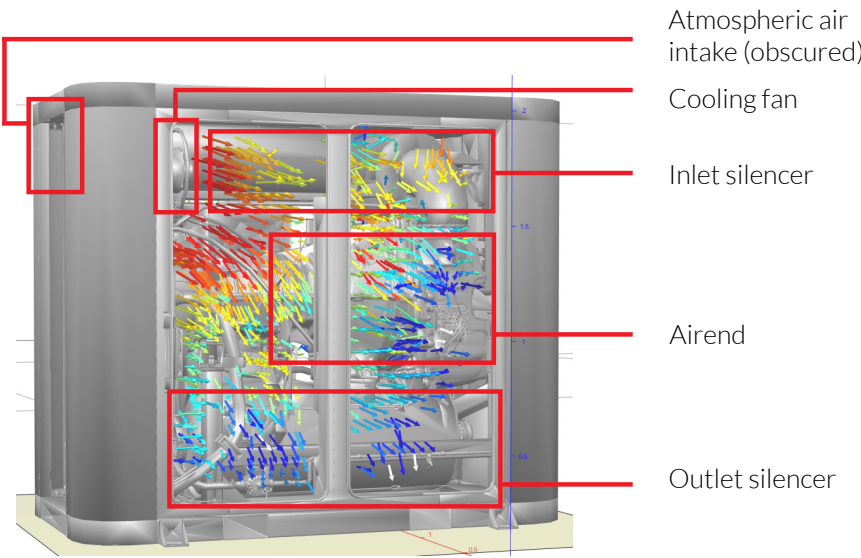


Figure 3: Reactive Intensity vectors covering 24-60Hz, covering the fundamental frequency of 42Hz at the running speed.



Figure 4: Comparison between Sound Pressure (left) and Particle Velocity (right) for 100-140Hz, covering the 3rd tone

125Hz was identified as an important frequency for noise emission from the enclosure, so it was important to identify its internal sources. Particle velocity should provide far better spatial resolution than sound pressure for the purposes of source localization. Figure 4 shows that while sound pressure suggests that both the atmospheric inlet region and the outlet silencer could be sources of 125Hz pulsation, particle velocity shows that it is most likely to be emitted by either the front of the airend or the front of the outlet silencer. This meant the new inlet silencer did not have to be optimised for 125Hz, which was an important design decision.

At higher frequencies, we analysed the spatial data in octave bands (Figure 5), as opposed to individual tones. One clear source was the inlet air pipe, which carries air from the inlet silencer to the airend prior to compression. This angled pipe is made of reinforced silicone, so greater emissions were to be expected compared to metal components. Being a soft material in comparison to metal components, emissions from this pipe could be used to give an indication of the spectra inside the pipe, as they should not contain any ringing modes of the pipe itself.

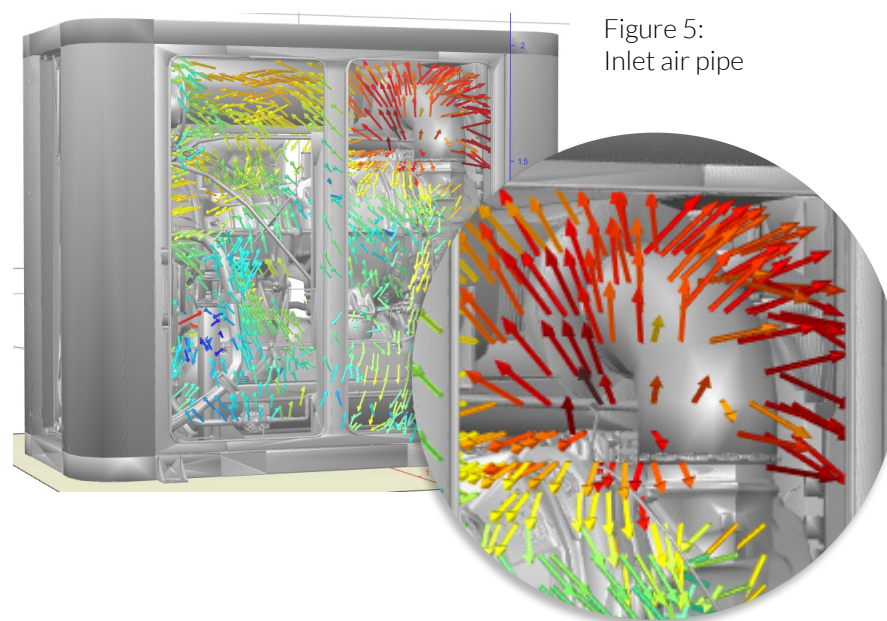


Figure 5:
Inlet air pipe

Defining a volume around the inlet pipe allowed a spatially averaged emission spectrum for it to be generated (Figure 6). This shows that the peak emission is around 200Hz (5th tone). Since this frequency is not prominent in downstream pressure transducers, it is most likely caused by reflected pressure waves between the silence and airend. This will need further simulations to confirm, but since it is not a prominent tone at the atmospheric inlet, it suggests the silencer is already effective enough at attenuating this frequency.

We know from the previously shown data that there is strong 125Hz content emitted inside the enclosure, so looking at this frequency on the external scans should highlight any unsealed gaps which may be allowing noise to egress. Other frequencies will be let out of these gaps as well, but looking at 125Hz should make them easier to identify in our particular case. Figure 7 shows that using this approach with narrow frequency bands, Scan & Paint allows identification of these small sources, such as the two loosely fitting doors highlighted here. The doors have rubber seals, but in this case, the fault was with incorrectly tensioned latches.

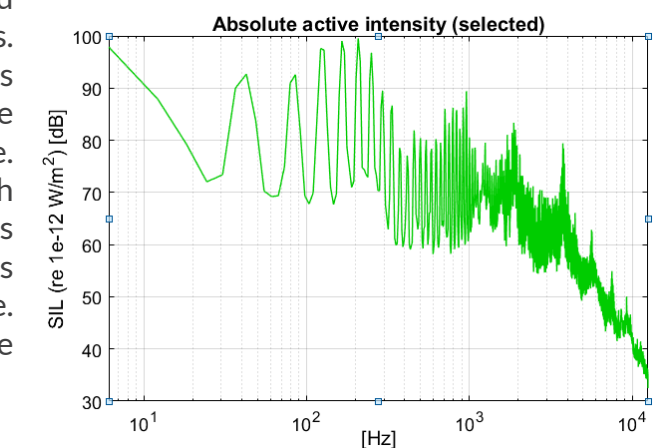
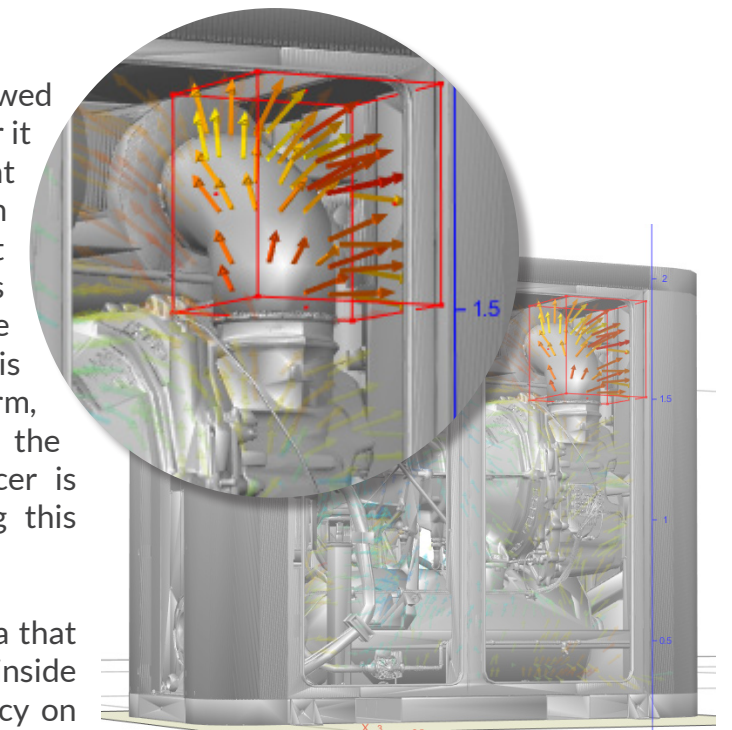


Figure 6: Intensity plotted within a volume around the inlet air pipe identified previously (left), and spectrum of the emitted noise (right).

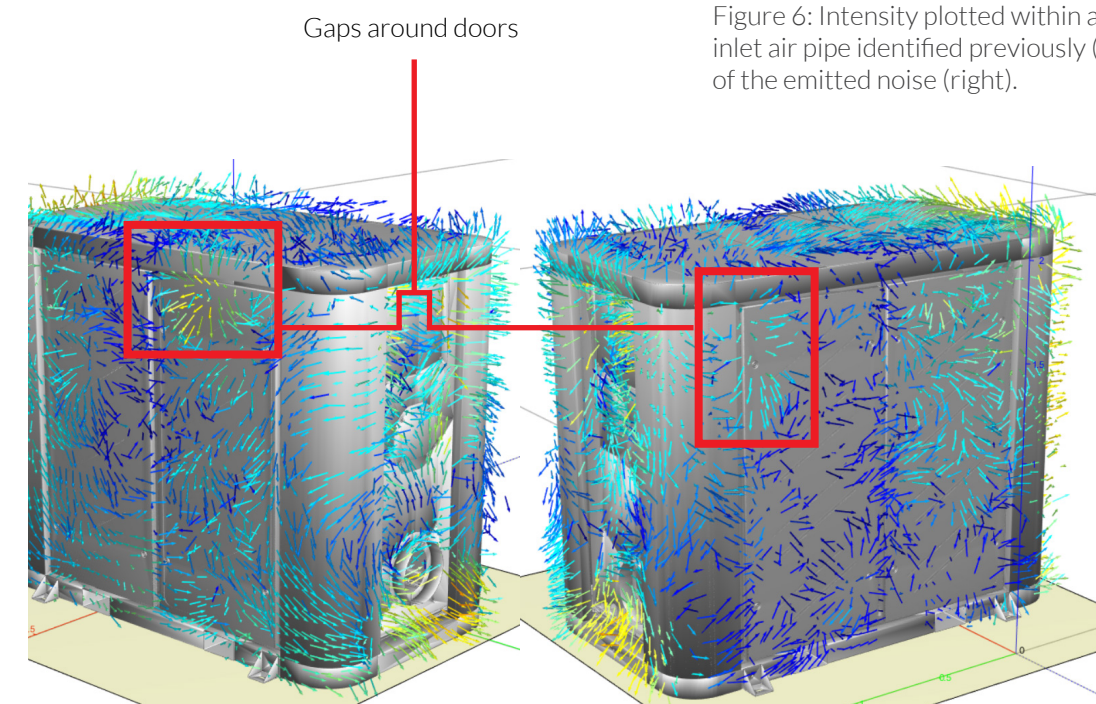


Figure 7: Active intensity outside enclosure for 100-140Hz.