Nor848A Acoustic camera

Identifying Low-Frequency Tonal Noise in Windy and Noisy Conditions

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Measurements on LNG gas terminal in Stavanger, Norway

Problem

A large LNG gas facility (approximately 300m x 150m) producing 300 000 tons of LNG annually is situated in a terminal area with the nearest populated area at a distance of around 1 km. Within the gas production facility, a low-frequency tonal noise at around 500 Hz is generated causing complaints from nearby neighbours. The tone imposes a more stringent noise requirement on the facility, forcing noise reducing actions being made on the source.

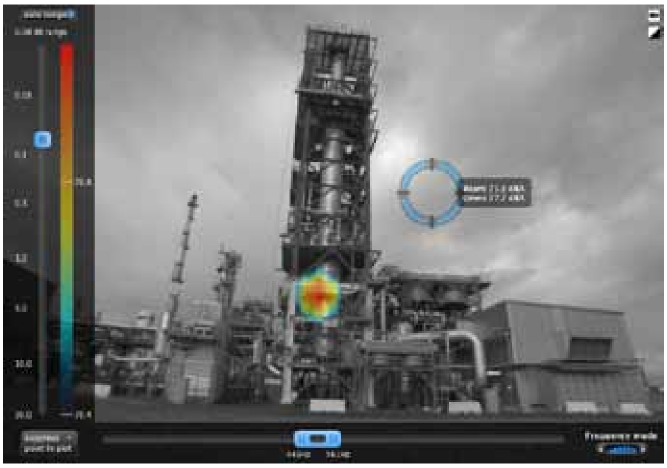
In addition to the tonal noise, the entire LNG gas facility is rich in noise emitting sources, including lossing and loading of maritime vessels, which further complicates the source location of the single tonal noise source. Also the location of the facility at the coastal regions of the western part of Norway, ensures that windy conditions are frequent, with wind noise further impeding the quality of acoustic recordings.

Based on measurements with hand held sound level meters, the problem area was narrowed down to be a large pipe in the midst of the facility. However it could not be determined if the emitted tonal noise was from the entire pipe itself, or if it originated at a specific part of the pipe. There was also uncertainty whether there existed multiple sources within the pipe, for instance at both the base and top layer. In the worst case the noise insulation would have to be performed over the entire pipe length, which could have been a very expensive solution.

Measurements

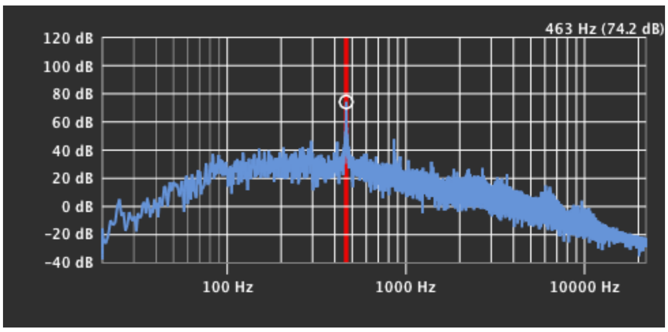
The measurements were conducted over two subsequent days with the Nor848A-10 1.0m and 256 element acoustic camera. The camera was plugged into an external battery pack for easy transportation and mobility. The entire measurement system could easily be moved around to different positions to get a noise mapping of different sides of the pipe. Different positions would also ensure that noise sources being different from the source of interest would

not inflict too much on the measurements. The primary measurements were conducted at a distrance of approiximately 25-30 meters from the pipe. In addition measurements were made close to the source from 2-5 m distance by climbing up onto the pipe with the camera. Since the flight of stairs were too narrow to get the 1.0 m camera through the stair's safety rails, this was solved by hoisting the camera up and down by rope.



Results

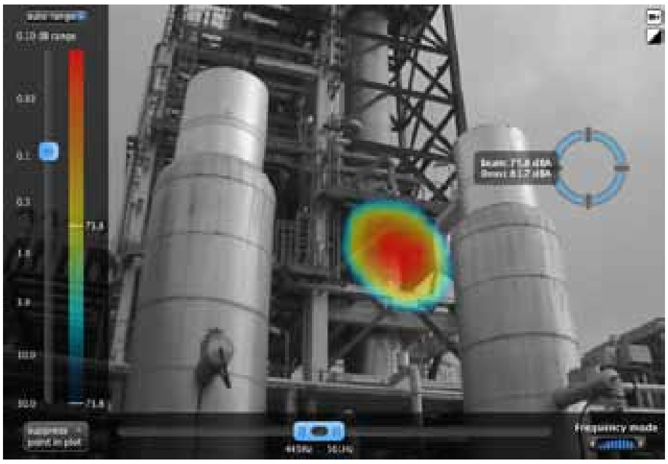
By positioning the center of the array towards the pipe and adjusting the frequency to display only coloring within the 500 Hz 1/3-band, the noise source was located within seconds, and the source producing the tonal part from the pipe was detected. Measurements from different measurement positions also confirmed the source location.

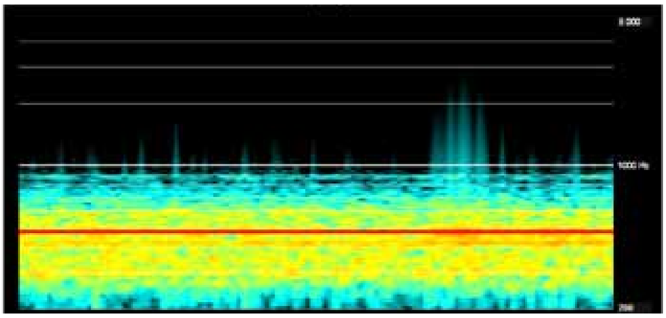


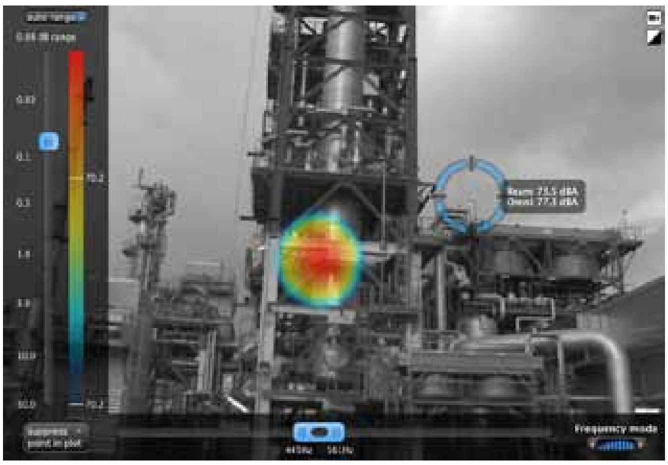
By placing the virtual microphone on the localised source and using the spectrogram function, it was easy to verify the position of the source emitting a tone at 460 Hz.

Although the measurement location had quite windy conditions, the wind noise did not affect the measurement results at all. Wind noise can be viewed as spatially white, which means that wind noise sampled at different places in space, as is done with the Nor848A, is not correlated from position to position. When many different signals from many microphones are added in the beamforming algorithm, the wind noise will be added out of phase and attenuated proportional with the number of microphones being used.

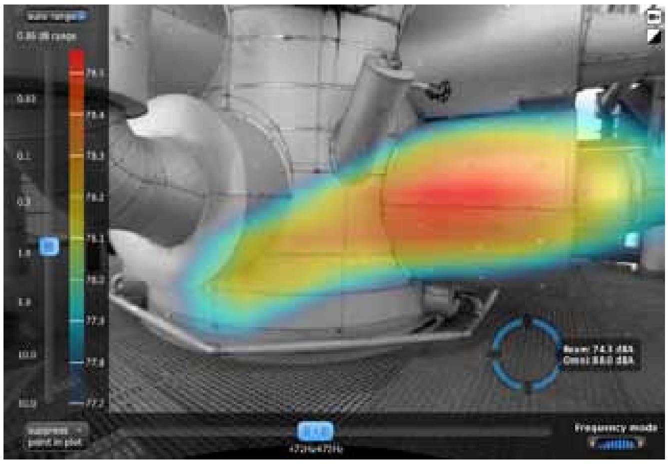
With the acoustic camera it was possible to detect the tonal sound of the most crucial parts of the turbine. This meant that the facility could focus on and implement noise reduction actions in the right places.







After pin ponting the location of the noise source, further analysis could be made with measurements performed closer to the source of interest in order to further determine the position and cause of the generated tonal noise.



Another useful function is the so called acoustic eraser, which is a functionality that enables source suppression in order to find interesting plotting points. Seen on the images from the acoustic camera software on the next page is a recording of the pipe without and with point suppression enabled. Seen in the bottom image, the acoustic eraser is seen as a red circle with a white x and placed on the tonal source in the image to suppress it. By enabling the acoustic eraser, and dragging the point suppressor to the desired location, one could further identify if the pipe had other locations that generated tonal noise. As seen in the bottom image, no such additional tonal sources were found.

Nor848A Acoustic camera

The Norsonic Nor848A acoustic cameras sets a new standard for acoustical cameras. The large number of microphones eliminates the problems of ghost-spots, compared to traditional acoustical cameras where the relatively low number of microphones increases the side lobe effect, resulting in the so called ghost- spot effect: You “measure” a non-existing source.

The Nor848A software is extremely intuitive and easy to use. Just after a few minutes of training, the user is able to operate the system and do real measurements. Three camera frontends are available, all varying in number of microphone sensors and size, where a larger array size ensures better resolution for lower frequencies: A 0.4 meter array holding 128 microphones, a 1.0 meter array holding 256 microphones and a 1.6 meter array with 384 microphones.

The digital microphone elements are protected behind a disc-shaped carbon fibre enclosure, and a dust and water repellent mesh is protecting the microphones from dust and moisture. The robust and sturdy construction also ensures that all microphones are kept in the correct position – important for field applications. The small distance between the microphones in the inner circle is important for low spatial aliasing at higher frequencies. The large number of microphones also contributes to the wide measurement range and the low self-noise. The signal in the selected direction is based on the weighted average of all microphones and is therefore far below the self-noise from a single microphone.

The system enables the user to perform noise analysis with a clear view of where the different noise sources are located in real time. The system is ready to measure in just a few minutes after entering the site. By moving the cursor in the picture you may analyze and listen to the sound in the selected directions while doing the measurements. This enables the user to identify the problem, whether it is an annoying sound, a leakage or other difficult noise problems in just a fraction of time compared to traditional methods.

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