Dinorwig Power Station

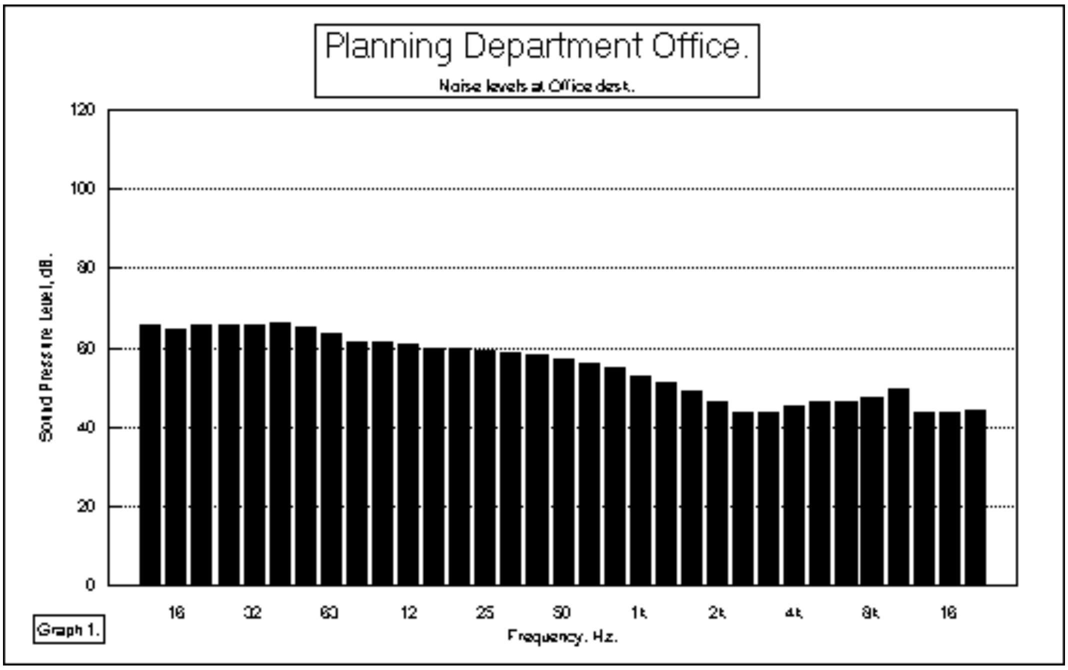
It is not every day that we are asked to investigate a noise problem inside a Welsh mountain, however this article will describe just that occurrence. PDA were asked to investigate a tonal noise problem inside a planning office at Dinorwig Power Station. Although this was not a problem in terms of the Noise at Work Regulations, it represented a serious problem. The impact of this noise problem was being felt, literally, in terms of fatigue, loss of concentration and significantly reduced productivity.

Firstly, let us look at the general situation. Dinorwig Power Station is situated in Llanberis, Gwynedd and is in effect a large capacitor. Water is stored in a reservoir on top of a mountain. At times of high demand, when people are putting the kettle on in the mornings or after Coronation Street, water pours through pipe work inside the mountain, spins the turbines and is deposited in a second reservoir at the bottom of the mountain. The electricity this generates is sold at a premium rate to the National Grid, as it is supplied at times when it most needs it. Then, at night, the water is pumped back up the mountain to the top reservoir, using electricity bought from the National Grid at a much lower off-peak rate.

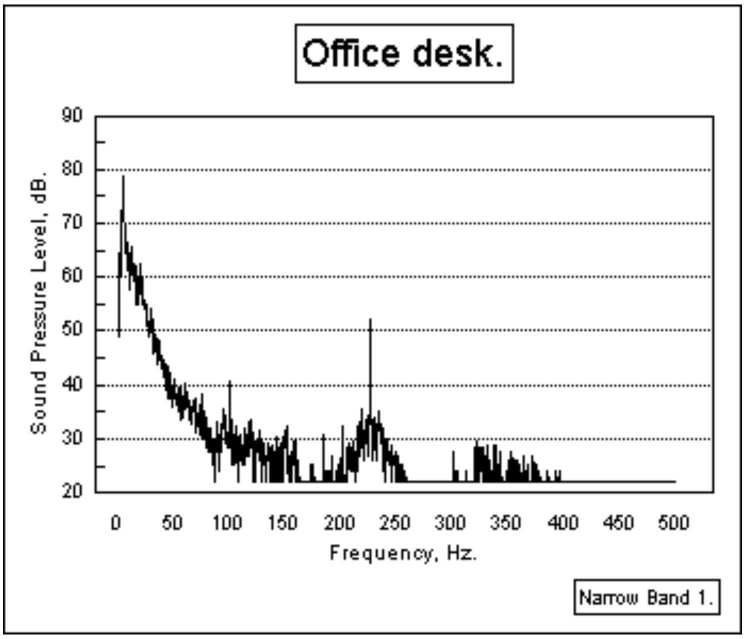
The scale of engineering of the site is breathtaking. The mountain contains a tunnel network so big one is given a map upon entering, the size of the tunnels are large enough for two medium sized lorries to pass side by side. The machine hall inside the mountain is some 25m high and is known as the ‘concert hall’. The station has eight floors, six turbines and even has a theatre for tourist visits, all deep inside the mountain

Faced with this engineering, it was somewhat daunting to be examining a problem that had foxed many other engineers previously asked to provide a solution. The office in question is situated on a level three stories above the turbines and one of the walls of the office is the mountain itself. Our initial reaction when hearing about this problem was the same as other engineers who had visited the office, that structure-borne vibration was finding it's way into the office and manifesting itself as airborne noise through lightly supported structures, and to solve the problem would involve some quite tricky vibration isolation of the office structure.

Our site visit was timed to coincide with the morning peak generating times. It had been noted by users of the office that the problem worsened when Turbine No. 6 was active. Upon hearing the tone generated when Turbine No. 6 started spinning it was immediately obvious why working in the office was so tiring. Apart from the high level of the tone, it was very difficult to localise any source. Walking around the office, the level of the tone varied but it was still extremely difficult to localise any source of the tone. As can be seen from Graph 1, a third octave band spectrum of the noise at the desk revealed no information about the problem at all, the tone was narrow enough not to contribute significantly to a third octave band.

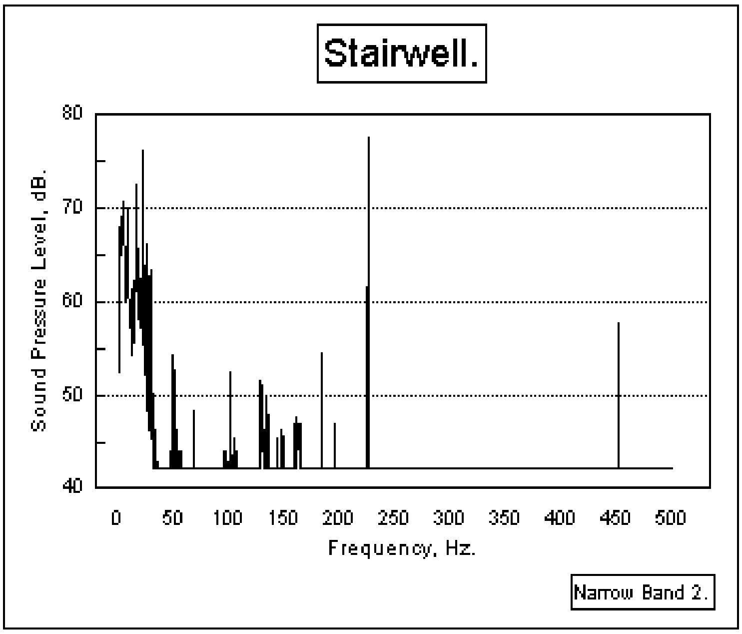


However, by switching to narrow band analysis the problem is instantly visible as shown in Narrow Band 1, with a tone some 25 dB above the background noise level. We had now established and quantified the problem, and were left with the simple task of finding and eliminating the source. This was made tricky by the inability to localise any source of noise. However, at least now we knew what we were looking for.



Our first tactic was to examine vibration in all surfaces inside the office, especially all lightly supported systems such as filing cabinets and plasterboard partitions. This was done in one third octave bands and narrow bands (0.1 Hz.) to track down the source of our tone. It was found that vibration in all the structures was so low that one third octave band analysis was simply of no value. Switching to our narrow band analyser we saw that, although a small amount of tonal vibration was present, calculations revealed that the levels were nowhere near high enough to produce the airborne tonal noise measured at 52 dB. It had to be concluded that the source of noise was not vibration in the structure.

Taking a leaf from Sherlock Holmes, after having eliminated all possibilities, we were left with the truth, no matter how impossible it seemed. The tonal noise must be airborne, thus travelling up three flights of stairs, through various doors and entering the office as airborne noise. Opening the office door onto the outside stairwell, the level of the tone grew higher. The second narrow band presented here shows the noise in the stairwell, our 225 Hz. tone is now some 18 dB higher. Again, there was very little vibration in the building structure, leading us further to the idea that the noise problem was airborne rather than structure borne. Descending down the stairs the tone was getting louder and louder until we reached the turbine level. Making a measurement one metre away from turbine No. 6 revealed our tone some 38 dB higher than we were measuring in the office.



Further investigation throughout the remainder of the station showed that vibration was indeed a problem in certain areas, and the 225 Hz. tone was causing resonance in all manner of structure. A wall of lockers had enormous amounts of vibration in them and were all behaving as loudspeaker cones, as were many office windows, air conditioning ducts and desks which were located nearer to the turbines. In effect, the turbines were generating airborne noise and vibration energy which was being amplified by a multitude of sources throughout the rest of the station.

With this huge amount of noise sources, it was not appropriate to use our normal approach of noise control at source. Back inside the office, various field level differences were measured. It was deduced that the tone was breaking in through the main office door and a door connecting the office to a neighbouring workshop. These doors simply needed replacing with acoustic doors, attenuating the tone by some 20 dB.

Another source of the tone was the air supply system. This needed treating by installing two straight through silencers, one for each of the two supply ducts serving two grilles near the office desk we were investigating. For such a complex noise source the eventuality was quite a simple solution. It was also a method exercise in using the most important piece of equipment every acoustician is supplied with, their ears. By aurally tracking the source down it was possible to solve quite a complex problem and provide an easy solution, whereas some theoretical solutions which had been previously offered such as floating floors and walls would have been very expensive and most importantly of all, not worked.

As was stated at the start of this article, tackling a noise problem inside a mountain is not the sort of thing we do every day, so our thanks go to Dinorwig Power Station for providing us with such a brain-teaser and also allowing us to write about it further.

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