YWCT
Custom Cooling Towers

Noise levels in cooling towers

General

The noise level, Sound Power Level (SWL) and Sound Pressure Level (SPL), is an important environmental parameter that affect the design parameters of a cooling tower and its appropriateness to the environment and the client's requirements. While SPL is relatively easy to measure directly using sound level meters, SWL is not measurable, as it is a theoretical value. SPL can be calculated thusly:

$$\text{SPL} = 10log\left(\frac{p^2}{p_{ref}^2}\right) = 20log\left(\frac{p}{p_{ref}}\right)$$

Where *p* is the measured SPL at a given point; and $p_{ref} = 20\mu Pa$ is the reference SPL

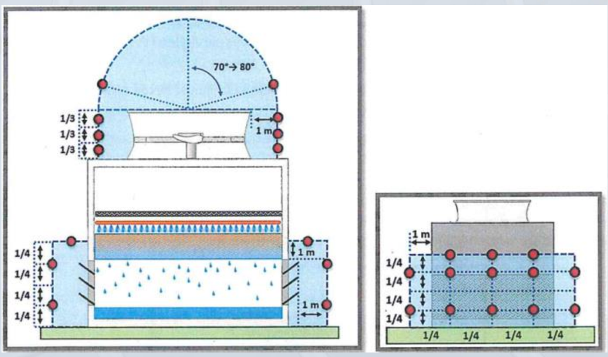
In general, the main noise locations in cooling tower are-

- Air inlet point – or the area in proximity to the louvers where the main source of noise is falling water
- Air outlet point - or the area of the fan housing where the main sources of noise is the fan movement and motor operation.

Calculating the noise level

There are many standards for conditions and processes for determining the SWL of a cooling tower. What they all have in common is that the SWL is calculated indirectly from the SPL measured at points and surfaces surrounding the tower. The main difference between all the standards lies in the points and surfaces at which the SPL must be measured in order to calculate the SWL. Other differences between standards: Some are based on near-field measurements, and others on far-field measurements; while others include both; some are intended for small towers, and others for large towers.

The measuring surfaces defined in the standards define enveloping surfaces (entire or partial) that enclose both noise sources in the tower. For example, DIN 45635, a common standard, sets the SPL measuring surfaces and points thusly:



The formula for calculating SWL within SPL in the abstract sense is:

$$\text{SWL} = SPL_{avg} + Corrections + Geometric\ Term$$

where $\boldsymbol{SPL_{avg}}$ is the average of all of the acoustic pressure levels at all points on the measuring surface as follows:

$$SPL_{avg} = 10log_{10}\left[\frac{1}{SA_T}\sum_{Point=1}^{n}(SA_{Point}\cdot 10^{(0.1SPL_{Point})})\right]$$

Corrections – the correction value, whose purpose is to take into account the effect of the noise on environmental properties such as background noise, echoes, direction, and atmospheric absorption. Usually when noise coming from external sources is valued at 10-15dB lower than that measured at source, it can be ignored.

Geometric term – a value expressing the area of the measuring surface (usually hemispheric in far field and rectangular in near field), and is calculated as follows:

$$Geometric\ Term = 10log_{10}(SA)$$

After measuring noise levels on the required surfaces, a total of the results would appear as follows:

Sound Power [dB(A)]	***Position (surface)***	$\boldsymbol{SPL_{Avg}}$	$\boldsymbol{SA\ [m^2]}$	***Geo. Term [dB(A)]***	***Sound Power [dB(A)]***
SWL_{S1}	S_1	SPL_{S1}	SA_{S1}	GT_{S1}	SWL_{S1}
SWL_{S2}	S_2	SPL_{S2}	SA_{S2}	GT_{S2}	SWL_{S2}
		…			
SWL_{SN}	S_N	SPL_{SN}	SA_{SN}	GT_{SN}	SWL_{SN}
$\boldsymbol{SWL_{TOT}}$	$\boldsymbol{S_{TOT}}$	$\boldsymbol{SPL_{TOT}}$	$\boldsymbol{SA_{TOT}}$	$\boldsymbol{GT_{TOT}}$	$\boldsymbol{SWL_{TOT}}$

A-weighting noise correction

While the sound level meters pick up the real (linear) spectrum values of the SPL, the sensitivity of the human ear to certain tones causes those tones to be heard differently than the measured values. Because the noise considerations in most cases are related to human hearing, noise values are corrected for at frequencies on the spectrum at the level of human hearing sensitivity. In general, the human ear is more sensitive to sounds at 1kHz-4kHz frequency, and therefore in the rest of the frequencies on the spectrum, the corrections are negative:

dB(L) to dB(A)							
63	125	250	500	1K	2K	4K	8K
-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1

Useful arrhythmic properties and behaviors of noise

- Adding "n" values of SPL: $SPL_{TOT} = 10log_{10}\left[\sum_1^n 10^{(0.1SPL_{Point})}\right]$
- Effect of distance from the noise source on SPL can be expressed by:
    - $SPL_{p_2} = SPL_{p_1} + 20log_{10}\left(\frac{r_1}{r_2}\right)$
- From the above we can conclude that doubling the distance from the noise source will lead to a 6dB reduction in the SPL.
- Each incremental multiple of the noise source leads to an increase of 3dB in the SPL at that specific point.

Techniques for reducing noise in cooling towers

Frequently a case arises wherein the noise level of a standard cooling tower exceed the client's environmental noise requirements. There are a number of ways to reduce the noise level of a cooling tower. Because the noise sources are mainly at two locations – the air inlet and air outlet – the noise reduction measures also relate to these two areas:

Air outlet -

- **Quieter fan** – A main noise source at air outlet point is the fan. One can now find special fans intended for use in cooling towers with stringent noise requirements. A good example is the Howden SX line of fans.
- **Reducing fan blade rotation speed** – The parameter that significantly affects fan noise is the fan tip speed: The faster the pan rotates, the noisier it will be. The fan blade rotation speed can be reduced by using a VFD system or using a higher reduction ratio (by a gear reducer). Usually reducing the rotating speed of the fan necessitates increasing the motor and the gear needed to obtain the ensured output.
- **Adding a sound wall of the circumference of the fan deck** – In certain cases, the client prefers that the tower noise carries in a certain direction(s), i.e., usually one needs to ensure low noise only in a certain direction, and there is no concern about other directions. In such cases, a wall can be added on the critical side of the tower, creating a continuation of the tower cladding. In this way, some of the noise (whose source lies in the air outlet) will be blocked and bounced back from the wall, which will manifest in lowered SPL values in this direction. Using this method, while the total SWL of the tower will not be reduced, the direction of the noise will be channeled.
- **Baffles and sound attenuators** – When there is a need to reduce the overall noise at the tower, but there is no preference for the direction of the noise, sound attenuators that form a "box" around the fan stack are used. The box "swallows" part of the noise and thus reduces the overall SWL level at the tower. At the same time, such a box also adds resistance at the tower air outlet (and increase in static pressure), which necessitates adjusting the mechanical system accordingly.

Air inlet into the tower

- **Closing the air entry opening** – This solution is essentially similar to the sound wall on the tower fan deck and is limited to closing the air entry openings only on the noise-sensitive sides of the tower. In certain cases, the air entry openings that are left open will need to be raised in order to maintain the required air supply for the tower's operation.
- **Thickening the tower cladding**– While usually the tower's exterior is considered to be a noise insulator, in fact it is not, and due to the walls' thinness, some noise gets through. The insulation can be improved by thickening the tower cladding.
- **Louvers –** Installing louvers at the air entry openings reduces the noise. For example, Brentwood CL-100 louvers are known to reduce SPL by 3dB as measured at the air inlet.
- **Water silencers –** The main noise source at the air inlet is from falling water. Reducing this noise source necessitates softening the water's fall. There are a number of ways to do this, the common ones being: mesh with a flotation device on the surface of the water; adding surfaces to the slope slightly above the water surface; or a combination of the two. Using one or both of these methods, water noise can be reduced by -7dB(A).
- **Acoustic wall and sound attenuators –** These solutions are essentially similar to those suggested for the tower air outlet area. In the event that there is a preferred direction for the noise, an acoustic wall can be added at a certain distance from the entryway that will reduce the noise behind it. When the objective is to reduce the overall SWL level, sound attenuators are added at every air inlet location.

Summary

Noise is an important environmental issue and the cooling tower's meeting clients' acoustic demands is a complex process. Two important noise parameters are SPL and SWL. While measuring SPL at a given locale is simple, calculating the SWL within the SPL is a complex process that is sensitive to many external factors, and differs from standard to standard. While there are many methods and tools for reducing noise emanating from cooling towers, knowledge and experience are needed to choose the optimum one(s) for the specific situation.