

Horn-Construction

User Manual

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This manual is about the instructions for the calculation and construction of a Back-Loaded-Horn (BLH) using the EXCEL spreadsheet <Horn_guide.xlsx>.

INTRO

Preliminary remark:

1. I created it many years ago along the EXCEL version of Office 2003 (as .xls) and then converted it to the current version (.xlsx). It must therefore also work with every new version. I also tried Open Office of the latest version and that also worked. In any case, be careful with Open Office, when saving as .ods again, all underlying formulas and macros are gone! If you need an older .xls version then please contact me, I still have it!
2. The sheet <chamber> - the calculation of the pressure chamber - is protected by password. The formulas behind it were not actually developed by me – I just inherited it, but it was also a lot of work for me to implement it after EXCEL and I want to keep it to myself. The sheet <calc> is also protected, but since these formulas are common knowledge, the protection only serves the purpose of ensuring that you do not mistakenly overwrite the underlying formulas.
3. The password is **horn**. Manipulations on the sheet should therefore only ever be carried out on a copy!!
4. The sheet <diagram> is also protected, but is only used for graphical representation. Again, the password is **horn**.
5. In principle, you can only make entries in cells with a green background. Cells with a purple background represent results. All cells that are not highlighted in green are locked.

DIRECTIONS FOR USE

Start with <chamber>

1. Here, the parameters of the driver are required. You can take the parameters from a data sheet or better measure them yourself, because manufacturer's specifications are often embellished.
2. The results are created automatically and are also automatically transferred to <calc>. Some cells have annotations (red corners in the upper right corner of the cell) – please read.
3. The theoretical volume of the pressure chamber is in the result of the V_{chamb} cell and the effective volume required for further calculations is V_{chamb_eff} . The change is caused by the fact that the pressure chamber has to be stuffed with wadding material, which virtually enlarges

it. The narrow slit at the entrance of the horn ($\rightarrow$ throat) must not be covered or obstructed by wadding material!

Now to <calc>

1. The general horn equation (pressure transformation) and the formula for the horn opening constant m are in the upper left.
2. The result of A_h is taken from the <chamber> calculation sheet and shown at the bottom right. f_3 is the -3dB frequency of the driver in the installed state. A_h is the calculated throat area of the horn. In this case, please do not confuse f_3 with f_3 in the construction of a normal cabinet, because there is actually no driver resonance with a horn.
3. Now look for the lower cut-off frequency f_g (for the horn) from the table on the left for m , which corresponds most closely to the value m from the calculation on the right, i.e. as close as possible to the value of 0,80917. You then enter it in the table at the top right of f_g . This is the value for the lower limit of the pressure transformation. i.e. down to this frequency the pressure transformation takes place and not deeper!
Attention: f_g must always be smaller than f_3 , otherwise distortions will occur!!
4. Now enter the value for the constant width of the horn in W_{const} . This will usually always be a little more than the outer driver diameter.
5. Then enter a value at H_0 and vary it so that the displayed value for A_h corresponds as close as possible to the calculated value in the red field (A_h was taken from <chamber>). Since smaller difference values than 1mm don't make sense, just try to get close $\rightarrow$ try it out!
The input for the value x is 0 for now.
6. At the same time, the table in the middle for "Distance, Area, Height, P. Transf." always changes simultaneously with your inputs. Now compare the values in the column *P-transformation* (= pressure transformation) with the value in the yellow highlighted cell at the bottom right (the one that was automatically calculated $\rightarrow$ "incl. losses from turbulence"). It leads you to x_{max} , i.e. the maximum length of the horn, where the pressure transformation has dropped from the high pressure in the chamber to normal air pressure. Compare the yellow value with the values in the "P-Transf." column. You read the corresponding length (distance x) in the table and enter it in the upper right corner at " x - distance from throat". Now you get the max. area of the mouth opening A_x in the top line and the corresponding height in the next line. You can now theoretically do this for any value of x and you will get the respective results. This can be helpful in mechanical construction.
7. Please understand that an extension of the horn beyond the value of x_{max} makes no sense, as a pressure transformation below normal air pressure is physically impossible!
8. For clarity, the table in the middle of the sheet is always automatically created with the results of points at a distance of 50mm from each other. If the value for x is not sufficient, remove the password protection (**horn**) and simply extend the table downwards. Please only ever perform this on a copy (!), because if you treat it incorrectly, the formula is gone $\rightarrow$ so be careful! Then turn the page protection back on immediately!

Please do not despair when irrational values are calculated for a driver and please understand that really only a small number of drivers are suitable for horn operation! Then this one isn't just suitable. This is especially true for very large ($>60\text{ l}$) or not possible small values for the volume of the pressure chamber. The ideal value for the volume of the pressure chamber is close to about 30 liters. This is easy to implement.

Suitable drivers have a large value for the force factor (B^*l) and have an average resonance frequency of 40 – 60Hz. Basically, a high efficiency and a small equivalence volume V_{AS} correlate, so pay attention to this when selecting the driver.

Compliance should deviate little, as it is largely responsible for the construction volume of the

pressure chamber. Therefore, drivers with so-called "soft edge" are not suitable. I.e. avoid foam edge or rubber edge, whereas paper edge or resin edge are the right ones.

Please don't get fooled by a relatively high resonance frequency f_s - the behavior in a horn is different from that of free radiation in a DIN baffle of 1 m x 1 m. A horn performs a pressure transformation, i.e. high pressure in the chamber is transformed down to normal air pressure and the energy inherent in the pressure is converted into velocity. Therefore, the parameters determined in a standard baffle are only relevant for the calculation, but not for the achievable results.

The calculated upper limit of the pressure transformation is the frequency up to which the pressure transformation takes place. The driver first radiates briefly like a transmission line and then similar to a closed box. At the same time, however, the radiation resistance beyond this frequency is already so big that support from a horn is no longer necessary. This is especially true for the high-frequency range. Due to the pressure transformation, the driver only makes very small strokes. Most of the time, they are only able to feel, but hardly visible. This supports the functionality of a dual-cone driver and the results are better than shown in the usual measurement notes. The influence of Doppler distortion due to a large stroke of the main diaphragm is also eliminated.

When choosing a FR-driver for your BLH, you should prefer drivers showing a soft-dome-alike dust-cap on top of the treble cone. That eliminates "beaming" in the highs by a remarkably big extent. An example was the K12H-100TC and the K12H-200TC (by Celestion).

When the horn is operated from a current-sourcing amp (CSA), the loss in SPL due to the increase in the impedance of the voice coil from increasing frequency is also compensated. Therefore, CSA are particularly preferred and recommended for the operation of such horn speakers.

The EXCEL spreadsheet is available for download here and the data for the SP30-PATC (by MONACOR) are already entered ... But you can change that at any time.

Good luck with design and construction, Barbara



If you have any further question, you can contact me via eMail.