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Design and Construction of a Pressure Chamber for Microphone Calibration with Electroneumatic Control

TEAM MEMBERS

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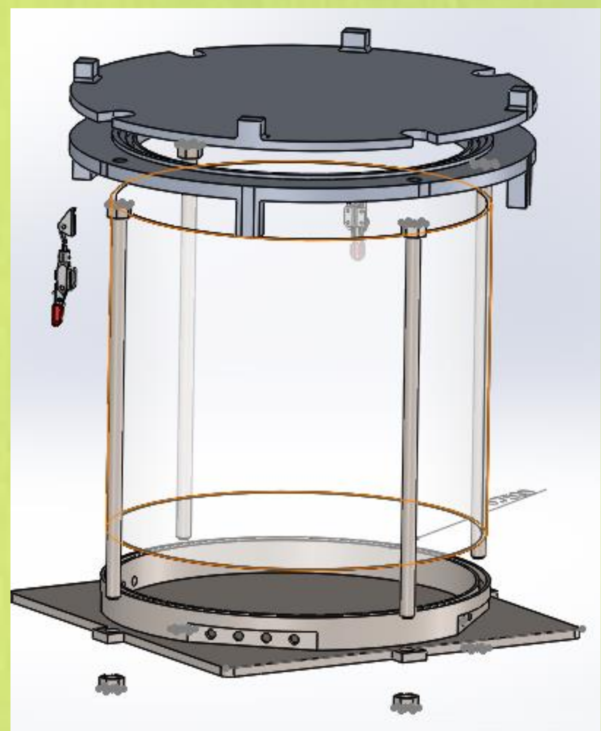
ABSTRACT

The acoustics team in CENAM use a pressure chamber to apply a pressure range corresponding to the different altitudes in Mexico for the primary calibrations of measurement microphones. The pressure chamber CENAM uses currently is not designed specifically for the calibration of microphones, therefore causing it to be complicated and inefficient. The current chamber door has eight screw and nut latches that take a minute each to tighten or untighten, is a heavy cubic structure made of steel with one small window, and uses a manual pressure control that is tedious to operate. The new chamber will be designed on SolidWorks and improve the existing problems like having faster access to the inside of the chamber, have a new cylindrical and transparent structure to allow the operator to see the entire inside and can distribute stresses evenly around the chamber. The removable lightweight top lid can be shut tightly using industrial clamps, and the use of elastic o-rings will keep the pressure from leaking out.

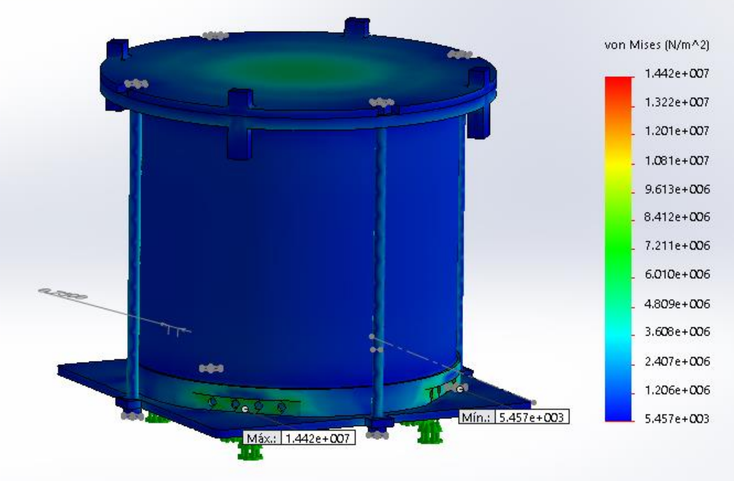
OBJECTIVES

Design and construct a lightweight structure of a pressure chamber for microphone calibration that has easy access to the inside of the chamber, a wide workspace to handle the microphones and can withstand a pressure range of 700hPa-1020hPa (10-15 psi) using an automatic pressure control that won't leak preasssure for the Acoustics Vibration lab in CENAM.

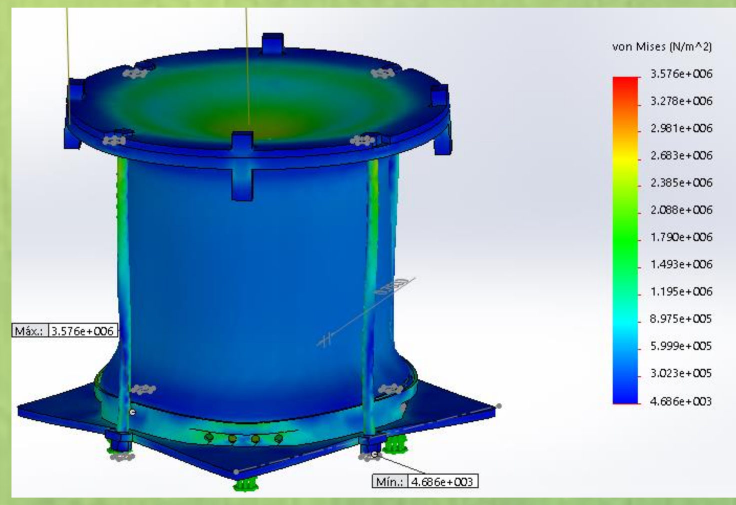
RESULTS



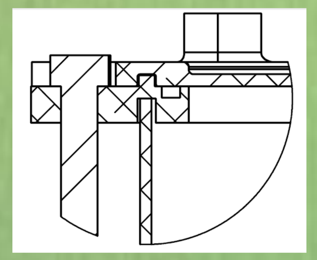
Exploded View of Final Design



Stress Analysis at 1020hPa



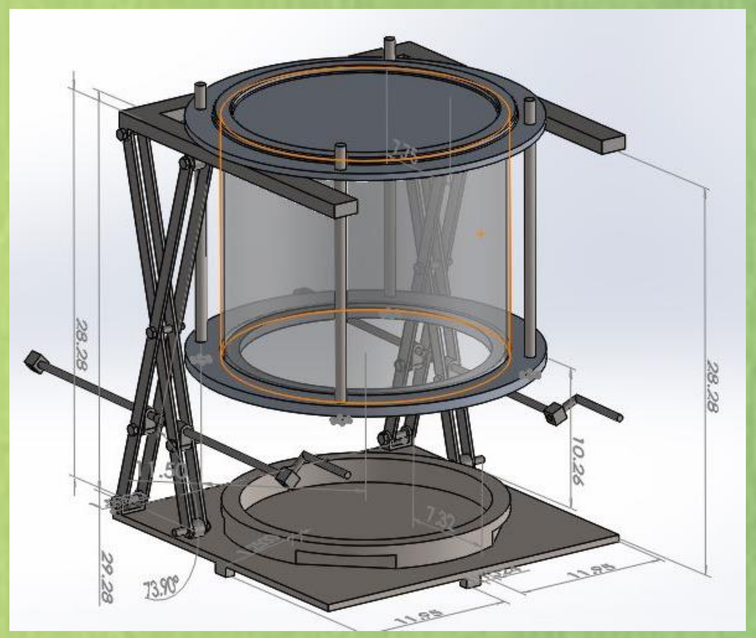
Stress Analysis at 700hPa



Detail of Ensemble

O-Rings:
- *2-468-N70*
- *2-465-N70*

Clamps:
- *Speedyblock T2X035*
- *Goodhand 40840*



2nd Design with Scissor Lift

Material	Elastic limits (N/m^2)
Acrilyc	4.5 e +07
Alluminum 7075	9.5 e +07
Stainless Steel 316	1.38 e+08
Nylamid	1.03 e+08

Compression Force Calculations

$d = seal\ thickness = 0.275\ in$

$D_m = seal\ mean\ diameter = 19.73\ and\ 18.23\ in$

$E = Young\ modulus = 1040\ psi$

$x = seal\ deflection = 0.04125\ in$

$$F = \pi d D_m E\left[1.25\left(\frac{x}{d}\right)^{1.5} + 50\left(\frac{x}{d}\right)^{6}\right]$$

$$F_{tube} = 1297.426\,psi = 5771.239\,N$$

$$F_{ring} = 1198.787\,lb_f = 5332.473\,\mathrm{N}$$

Contact Stress

$$f' = \frac{4F}{2.4\pi^2 x D_m}$$

$$f'_{tube} = f'_{ring} = 269.203\,psi = 1197.474\,\mathrm{N}$$

Torque Per Rod

$$F_b = \frac{F}{\sin 60} = \frac{2T}{d \sin 60} = \frac{F_{comp}}{4}$$

$$T = 62.5404\,lb \cdot in$$

BACKGROUND

Measurement microphones are condenser devices that are generally used for audio analysis tests such as (NVH) tests in the automotive industry. In order to calibrate these, pistonphones are used as a sound source that uses closed coupling volume to generate a specific sound pressure. Since pistonphones are greatly affected by ambient pressure a pressure chamber is used to control the surrounding pressure during calibration tests. Primary calibrations are often done in National Measurement Institutes because their laboratories are certified and traceable to primary standards.

METHODS

The design conception began by analyzing different designs of pressure chambers used for the same application and sketch a rough design of how the design would work according to the given specifications. The initial restrictions were the dimensions of parts that couldn't be tailored, such as the acrylic tube, o-rings and connectors. These were defined and both stress calculations and 3D model analysis on Solidworks helped prove that the design can withstand the pressure range as the thickness and shape of the lids were varied.

CONCLUSIONS

Every design process is an iterative production to get a final product, where a first preliminary sketch is revisited numerous times to fully define and finish every detail of the design. The final design is built to hold the specified 700-1020hPa pressure range and fit the required connectors, clamps and o-ring seals. Currently an Acrylic/Nylamid chamber is being produced by CENAM, teaming with CIATEQ.

REFERENCES

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