Duct Acoustic Standing-Wave Frequencies vs Vortex Shedding

Transverse acoustic standing-wave frequencies across a gas duct from its width and the gas speed of sound, and their ratio to a vortex-shedding frequency.

Method: Transverse standing waves f_n = n c/(2W); c = √(γRT/M); Blevins; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Duct width (across the tubes, along the shedding direction)	6.0000	m
Gas temperature	400.00	°C
Ratio of specific heats	1.3500	
Gas molar mass	28.500	kg/kmol
Vortex-shedding frequency	80.000	Hz

Calculated results

Parameter	Value	Unit
Speed of sound	514.89	m/s
First mode	42.908	Hz
Second mode	85.816	Hz
Third mode	128.72	Hz
Shedding to first-mode ratio	1.8645	

Notes for this case

- Shedding within 20 % of acoustic mode 2: risk of acoustic resonance (loud tone, baffle damage).

Formula and method

$$c = \sqrt{\frac{\gamma R T}{M}}, \quad f_n = \frac{n c}{2 W}$$

Variables

W	Duct width (across the tubes, along the shedding direction)	m
T	Gas temperature	K
γ	Ratio of specific heats	-
M	Gas molar mass	kg/kmol
f_v	Vortex-shedding frequency	1/s
C	Speed of sound	m/s
f_1	First mode	1/s
f_2	Second mode	1/s
f_3	Third mode	1/s
f_v/f_1	Shedding to first-mode ratio	-

Method and standards

Transverse standing waves across the duct width: the n-th mode has n half wavelengths across W, at the ideal-gas speed of sound. The calculator warns when the shedding frequency is within 20 % of any of the first five modes, a common screening band; the first three modes are shown.

Assumptions and limits

- Rigid duct walls.
- Free-gas speed of sound: in a dense tube bank the effective speed of sound is lower (by about $1/\sqrt{1+\sigma}$ with σ the bank solidity), so the true mode frequencies are somewhat lower than shown.

References

• Transverse standing waves f_n = n c/(2W)
• c = √(γRT/M); Blevins
• Flow-Induced Vibration
• 2nd ed. (Van Nostrand Reinhold, 1990); Eisinger
• papers on tube-bank acoustic resonance

Report details

Report reference	FCC-92PY-M3WK (the same inputs always give the same reference)
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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/boiler-pressure-parts/duct-acoustic-resonance

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.