

AEROLAB - Validation Report

Version 4.3 · 20 October 2026 · Schicht-Werk, Tulln an der Donau, Austria · core 1.1 (English translation of 02_Validierungsbericht_AEROLAB.md; the German text prevails) Raw data: 04_META/validierung_ergebnisse.json, 04_META/beispielergebnisse.json. Re-check: node 05_BUILD/validate_physics.js and node 05_BUILD/beispiele.js.

1 Result in brief

AEROLAB is **suitable for comparing shapes in the laminar range**. Absolute coefficients agree well with the literature for cylinders when wall blockage is small; for profiles an independent reference is missing. The literature comparison values were set from domain knowledge without online research and must be checked against the originals. No measurement is available.

Check	Result	Assessment
Cylinder Re 20, Cd	2.43 (10 % blockage), 2.33 (5 %); free about 2.05	deviation from wall blockage, 13 to 19 %
Cylinder Re 40, Cd	1.81 (10 % blockage), 1.62 (5 %); free 1.5 to 1.6	within range at 5 % blockage
Grid independence, cylinder Re 40 (L = 16 vs 32)	Cd 1.81 vs 1.83	good
Cylinder Re 100, Strouhal number	0.168 (5 % blockage, L = 12), 0.179 (10 % blockage, L = 16); free 0.164	passed; blockage raises the value as expected
Cylinder Re 100, Cd	1.45 (5 %), 1.52 (10 %); free about 1.3 to 1.4	deviation from blockage, 4 to 12 %
Grid independence, NACA 0012, Re 200 (L = 24, 32, 48)	Cd 0.299 / 0.304 / 0.296	good (about 3 %)
Plate parallel, Re 500, Cd	0.175 (friction per Blasius 0.059 plus leading-edge pressure part)	order of magnitude plausible, parts not separately demonstrated
Symmetry NACA 0012, $\alpha = 0$	Cl between -0.008 and +0.013	passed (zero offset about 0.01)
Sign and size of lift	Cl rises with α , NACA 2412 gives positive lift at $\alpha = 0$	passed (trend)
Profiles, absolute Cd	about 0.30 at Re 200	open: probably too high by domain knowledge; undecidable without an independent reference value

2 Consequences for use

1. Shape comparison at equal Re, equal blockage and equal resolution is admissible; do not pass on absolute profile coefficients.
2. Strouhal numbers for cylinders are usable (chord at least 12 cells, blockage at most 10 %).
3. The optimisation gives directions: in the example (NACA, Re 300) the glide ratio rises on verification from 0.92 to 1.96 (angle of attack 8.6°, thickness 8 %).

3 Finding: lift oscillation on profiles (resolved)

In core 1.0, profiles showed a lift oscillation from about 4° angle of attack with $St \approx 0.76$, whose amplitude grew with resolution. Initial perturbation, domain boundaries (additional absorbing zone at the inlet) and lattice Mach number were examined. Neither the initial perturbation nor the boundary zone changed the oscillation; halving the lattice velocity from $U = 0.08$ to 0.04 (and likewise 0.06 and 0.05) removed it while the means stayed the same (Cd 0.245, Cl 0.28 at $\alpha = 6^\circ$). The cause is therefore the compressibility of the method at lattice Mach number 0.14. The default was lowered to $U = 0.06$ (Mach 0.10); all computations were repeated (table above). Profile polars have been steady since. ### 3.1 Additional test, NACA 0012 at further Re and angles of attack

Chord 24 cells, default wall, angles of attack 0, 4, 8, 12°, up to 30 chord times (raw data: 04_META/zusatztests_profile.json):

Re	Cd (0 / 4 / 8 / 12°)	Cl (0 / 4 / 8 / 12°)	Behaviour
100	0.444 / 0.450 / 0.470 / 0.500	-0.01 / 0.19 / 0.38 / 0.54	steady, converged

500	0.183 / 0.194 / 0.218 / 0.253	0.01 / 0.19 / 0.31 / 0.43	steady up to 8°; unsteady at 12° (St 1.2), not reliably converged
1000	0.131 / 0.146 / 0.177 / 0.228	0.02 / 0.16 / 0.26 / 0.42	unsteady in all cases (St 1.0 to 1.15), not reliably converged

Lift rises with angle of attack and drag falls with Re, as expected from domain knowledge; the ranking of angles is plausible throughout. At Re 1000 the frequency found ($St \approx 1$) is wake shedding in a two-dimensional computation at coarse resolution or a numerical part; the two are not separated. Check at finer resolution (Re 1000, 4°, chord 48 instead of 24 cells; 04_META/zusatztest_re1000_L48.json): still unsteady (St 1.02), Cd 0.133 (before 0.146), Cl 0.20 (before 0.16). The oscillation therefore persists at double resolution and is not a pure coarse-grid artefact, but the means are not grid-independent (deviation about 10 to 30 %). Conclusion: for profiles, Re up to about 500 and angles up to 8° are reliably comparable; above that, as a trend only.

4 Open points

- Obtain an independent reference for profile coefficients (published computation or measurement at Re 100 to 1000) – open.
- Re 1000: oscillation persists at $L = 48$, means not grid-independent; cause (two-dimensional wake shedding versus numerical part) not separated – open.
- Repeat cylinder Re 100 with $L \geq 24$ – open.
- Test the interface in Firefox, Safari and on real smartphones – open (Chromium checked, including smartphone emulation at 390 px width).
- Measurement on a printed test body – open.

5 Literature (not checked against originals)

- Dennis, S. C. R.; Chang, G.-Z. (1970): Numerical solutions for steady flow past a circular cylinder at Reynolds numbers up to 100. Journal of Fluid Mechanics 42.
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- Bouzidi, M.; Firdaouss, M.; Lallemand, P. (2001): Momentum transfer of a Boltzmann-lattice fluid with boundaries. Physics of Fluids 13.
- Ladd, A. J. C. (1994): Numerical simulations of particulate suspensions via a discretized Boltzmann equation. Journal of Fluid Mechanics 271.
- Krüger, T. et al. (2017): The Lattice Boltzmann Method – Principles and Practice. Springer.

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