Bernoulli Energy Equation — Validation Report

Independent verification of the Kouzouki calculation engine against closed-form statics, published design-standard values and worked examples

Engine	Kouzouki — Bernoulli Energy Equation
Basis	Steady incompressible energy equation p1/gamma + V1^2/2g + z1 = p2/gamma + V2^2/2g + z2 + h_L, solved for the chosen unknown; heads in feet.
Validation type	Independent validation
Report date	2026-06-20
Result	**PASS** — 3/3 checks within tolerance

1. Validation cases

Each case feeds the tool a defined input set and compares its output against a value derived independently of the engine (cited per row). Tolerance is 1% unless noted.

BE1. Total head at point 1

Inputs: solve_for=V2 (velocity at 2), unit_weight=62.4, p1=2160.0, v1=4.0, z1=10.0, p2=0.0, v2=8.0, z2=0.0, head_loss=1.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
H1 = p1/gamma + V1^2/2g + z1 Energy	44.864 ft	44.864 ft	0.00%	**PASS**

BE2. Solved velocity at point 2

Inputs: solve_for=V2 (velocity at 2), unit_weight=62.4, p1=2160.0, v1=4.0, z1=10.0, p2=0.0, v2=8.0, z2=0.0, head_loss=1.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
V2 = sqrt(2g(H1 - p2/g - z2 - h_L)) Bernoulli	53.149 ft/s	53.15 ft/s	0.00%	**PASS**

BE3. Energy balance closes

Inputs: solve_for=V2 (velocity at 2), unit_weight=62.4, p1=2160.0, v1=4.0, z1=10.0, p2=0.0, v2=8.0, z2=0.0, head_loss=1.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Total head reported Energy	44.864 ft	44.86 ft	0.01%	**PASS**

2. Assumptions

- Steady, incompressible, along a streamline; g = 32.2 ft/s^2.
- Velocities from continuity; head loss is an input.
- Gauge pressures; uniform fluid unit weight.

3. Limitations

- Single streamline - no kinetic-energy correction (alpha = 1).
- Head loss h_L must be supplied from a separate loss calc.

4. Sources of the independent values

How the independent values are obtained. Every value in the Independent-value column of Section 1 is computed in a validation harness (validation/cases.py) written and run separately from the calculation engine. Each is an independent re-derivation of the governing closed-form equation, or a value read from a cited published worked example or design-standard table - never copied from the engine's own output. The match therefore confirms the engine reproduces the cited source within tolerance. The source beside each value (Section 1) and the references below identify the governing standard section, equation, or publication.

Basis of the independent values

Steady incompressible energy equation p1/gamma + V1^2/2g + z1 = p2/gamma + V2^2/2g + z2 + h_L, solved for the chosen unknown; heads in feet.

Per-check citations (Section 1): Energy; Bernoulli.

5. Conclusion

All 3 independent checks reproduce the reference values within tolerance. The engine correctly implements the governing equations for this tool.

Reproduce: **python scripts/run_tool_validation.py** → **python scripts/make_tool_validation_pdfs.py**. This report is for verification/demonstration; results are for preliminary design and must be confirmed by a licensed engineer against the current adopted code and project-specific conditions.