Practical HVAC & Commissioning Handbook

Clear Air Solutions · New Zealand · Reference checked 25 October 2026

Understand the reading. Verify the system.

Pressure, airflow, water flow and commissioning evidence, explained for practical building-services work in Aotearoa New Zealand.

An original introductory field guide, checked against the references below on 25 October 2026. Use the approved design, project specification, exact equipment documentation and agreed test methods for acceptance. This guide does not reproduce a licensed industry handbook or set universal compliance limits.

Always identify the reference and the measurement station.

A number labelled “pressure” is incomplete without a unit, its location and what it is measured against. A negative inlet gauge reading is not a negative absolute pressure. Air ducts often use Pa; water circuits commonly use kPa or metres of the actual pumped liquid.

Common pressure terms in air and water systems

Term	Meaning	Practical distinction
Static pressure, p_s	Local fluid pressure. A gauge reading is relative to its reference, usually local atmosphere.	In an air duct it can be above or below room pressure. A correctly installed static tap avoids facing into the flow.
Velocity pressure, p_v	For low-speed air: $p_v = \rho v^2/2$.	It depends on density and local mean velocity. A Pitot-static probe derives it from total minus static pressure.
Total pressure, p_t	For the same low-speed air station: $p_t = p_s + p_v$.	Do not compare an upstream total reading with a downstream static reading and call that component loss.
Differential pressure, Δp	Pressure at one station minus pressure at another, in a declared order.	State the high/low connections. Across a coil, valve, filter or fan the correct tap pair determines what the reading represents.
Suction / inlet pressure	Pressure at the chosen inlet station of a pump or fan.	A pump suction gauge can be positive in a pressurised circuit. “Suction” describes the side, not necessarily a vacuum.
Discharge / outlet pressure	Pressure at the chosen outlet station.	Outlet gauge pressure alone is not the pressure rise across the machine. Subtract the inlet pressure and consider the appropriate energy terms.

Term	Meaning	Practical distinction
Absolute pressure	Gauge pressure + local atmospheric pressure.	Use a consistent absolute basis for vapour-pressure and NPSH assessments. Atmospheric pressure changes with altitude and weather.

References: Greenheck: Vane Axial Application and Design, pressure concepts; KSB Pump Lexicon: Pressure.

Static rise and fan static pressure are different quantities.

Fan total pressure (FTP) = $p_{t,out} - p_{t,in}$

Fan static pressure (FSP) = FTP − $p_{v,out}$

Static-pressure rise = $p_{s,out} - p_{s,in}$

The AMCA-style FSP definition subtracts outlet velocity pressure. It is not generally the difference between two static taps. Use stations, fan outlet area and installation category consistent with the selected performance curve; a convenient remote duct reading is not automatically a fan-rating measurement.

A fan has no single pressure attached to its type. Its operating flow and pressure come from the intersection of the actual fan curve and system resistance curve. Confirm model, size, rotational speed, blade pitch where applicable, density, installation arrangement and the curve's pressure basis. Elbows or obstructions close to the fan can produce system effects not represented by a simple straight-duct calculation.

Fan families: selection considerations, not pressure ratings

Family	What to consider
Propeller axial	Often used for relatively unrestricted ventilation. Verify performance with the installed guards, shutters and louvers.
Tubeaxial / vaneaxial	Axial flow through a casing; vanes and blade settings affect the curve. Check stable operating range and total/static rating basis.
Centrifugal	Forward-curved, backward-inclined/curved, airfoil and radial arrangements have different efficiency, power and application characteristics.
Mixed-flow / plenum arrangements	Evaluate the complete assembly, outlet environment and manufacturer selection data. The impeller label alone does not establish available external pressure.

At comparable points for the same fan geometry, speed changes approximately follow $Q \propto N$, pressure $\propto \rho N^2$ and shaft power $\propto \rho N^3$. These affinity relationships are not a guarantee of a new system duty; controls, efficiency, stall limits, motor loading and the system curve still matter.

References: AMCA: Straightening Out Fan Curves; ASHRAE: Fans, SI chapter. Use the fan pressure and affinity calculators for explicit assumptions.

A duct area does not have one universal maximum airflow.

For actual volumetric flow, **Q = A × v**. Use internal free area after lining or obstructions, and a representative mean velocity. For a rectangle A = width × height; for a circle A = πD²/4. A selected velocity limit gives a conditional flow capacity, not an automatic code-compliant maximum.

Choose that limit from the design's acoustic, pressure-loss, energy, leakage, construction, vibration and terminal requirements. A duct can physically convey more air while producing unacceptable noise or loss. Air-change calculations alone do not establish outdoor-air compliance, contaminant control or effective room air distribution.

Straight-duct loss: $\Delta p = f_D(L/D_h)(\rho v^2/2)$

Local fitting loss: $\Delta p = K(\rho v_{ref}^2/2)$

The first expression uses a **Darcy** friction factor, not a Fanning factor. $D_h = 4A/\text{wetted perimeter}$; for a rectangle it is $2ab/(a+b)$. Using hydraulic diameter with a round-duct friction model is an approximation, especially for high aspect ratios or non-uniform flow. Do not confuse hydraulic diameter with an equal-friction equivalent round diameter.

Calculate each run segment at its own flow and area. Add the appropriate fitting losses and the manufacturer's coil, filter, damper, terminal, silencer and louvre losses at the relevant duty. Each K must use the velocity basis stated by its source. Do not count a fitting both as K and equivalent length. A static-pressure change through a transition is not automatically its total-pressure loss.

The index path is the route that governs the required duty, not necessarily the longest route. Add losses in series along a path; do not sum the full losses of all parallel branches. Account for supply and return/extract paths and the fan installation arrangement when forming the system requirement.

Continuity reference: NASA Glenn: Conservation of Mass. Fan/system pressure context: ASHRAE: Fans, SI chapter. The duct calculator shows its method, limits and intermediate values.

Pump head is an energy difference, expressed as a height.

$H = (p_d - p_s)/(\rho g) + (v_d^2 - v_s^2)/(2g) + (z_d - z_s)$

Use pressure in Pa, density in kg/m³, velocities in m/s and elevations in m. The result is metres of the pumped fluid. Pressure and elevation must refer to the same defined stations, allowing for gauge/tap arrangements. If the two stations have equal velocity and elevation, only the pressure-difference term remains. Do not assume that simplification when pipe sizes or tap heights differ.

For water at an assumed density of 1,000 kg/m³ and standard gravity 9.80665 m/s², one metre corresponds to 9.80665 kPa. Hot water or glycol has different properties; use the actual fluid data. A water differential-pressure gauge does not directly read metres of glycol head.

In a filled, hydraulically closed circulating system, the upward and downward elevation contributions around the complete circuit balance. The circulating pump chiefly overcomes circuit resistance; do not simply add building height to that duty. Nevertheless fill pressure, expansion-vessel conditions, highest-point pressure and component pressure ratings remain important. Open systems and different free-surface levels require a separate static-lift assessment.

NPSH available is not the same as pump differential head. Its assessment needs an absolute inlet-pressure basis, fluid vapour pressure at operating temperature, velocity/elevation conventions and the applicable

manufacturer’s required NPSH and margin. A negative suction gauge reading alone cannot prove cavitation, and a positive reading alone cannot rule it out.

References: KSB Pump Lexicon: Head; Grundfos NZ: Heating-pump head and building height; KSB Pump Lexicon: NPSH. Use the pump-head calculator for a declared pair of stations.

Check the method before adjusting the plant.

Air measurements

• Identify actual versus standard volumetric flow and the density basis used by the instrument.

• Use a suitable traverse plane and point layout from the agreed method. Swirl, obstructions and short straight lengths increase uncertainty.

• For a Pitot traverse, convert each valid velocity-pressure reading into velocity before applying the method’s averaging or area weighting. Taking the square root of the average pressure is generally different.

• A centreline reading is not a substitute for an agreed full traverse. Flow hoods can influence the terminal flow; use the instrument’s correction or compensation method.

• Record duct internal dimensions, probe orientation, instrument range, zero checks, calibration status, density assumptions and operating mode.

TSI: Duct traverse application note TSI-106, Rev C; ASHRAE: Measurement and Instruments, SI chapter.

Water measurements

• Identify the exact valve part number, size, generation, setting and measurement-tap arrangement. DN alone does not identify Kv.

• Confirm whether the manufacturer uses a variable-orifice Kv, a fixed measuring-orifice coefficient or an instrument-specific characteristic.

• Check instrument zero, range and fluid settings in accordance with its instructions. Distinguish pressure across the valve body from pressure across a dedicated measuring element.

• Record fluid type, concentration and temperature. Density and viscosity corrections are not interchangeable; a specific-gravity correction alone does not validate a manufacturer’s chart for every mixture.

• Use a verified flowmeter or the exact supported manufacturer method for pressure-independent valves; do not assume ordinary $Q \propto \sqrt{\Delta p}$ across the whole assembly.

Use the valve calculator’s source register and supported-model notes before using any automatic lookup.

Controls and trend evidence

• Check point identity, units, scaling and sensor location against a suitable reference instrument.

• Compare command, feedback and physical response; a displayed “open” command does not establish valve or damper travel.

• Synchronise clocks and trend the variables needed to explain the sequence: mode, occupancy, setpoint, measured value, actuator demand, equipment status and relevant conditions.

• Choose a logging interval that captures the event and retain raw data with the test record. Restore temporary overrides under the agreed procedure.

US Department of Energy: HVAC Commissioning; Natural Resources Canada: Existing-building commissioning phases.

Use equations as checks, not as acceptance criteria.

• **Check units first.** Millimetres must become metres before calculating SI area; kPa must become Pa before using pressure in an energy equation.

• **Use the design duty and specified tolerance.** No blanket ±10% airflow rule applies to every space, system, standard or project.

• **Balance under the intended operating conditions.** Record door positions, VAV demand, filter condition, control modes and simultaneous plant operation.

• **Separate outdoor air from recirculated supply air.** A room can have substantial supply flow and insufficient outdoor air.

• **Question very small differential readings.** Instrument resolution, zero drift and disturbed flow can dominate the derived result.

• **Use fluid properties consistently.** Air density changes with conditions; glycol changes both hydronic heat capacity and hydraulic performance.

• **Recheck the whole system after a local change.** A speed, damper or valve adjustment can redistribute flow elsewhere.

• **Record uncertainty and limitations.** A rounded display does not establish measurement accuracy.

Example velocities, pressure gradients, air changes and heat-load factors are assumptions to evaluate, not default design rules for all buildings. There is no single “Pa per metre”, “L/s per square metre” or “fan pressure by fan type” that applies universally.

Connect every test to a requirement and an outcome.

Stage 1 — Design review and test planning

Agree the owner’s requirements, design intent, system boundaries, acceptance criteria, responsibilities, witnessing and test records. Review access, measurement points, controllability, schedules and how full-load or seasonal conditions will be demonstrated.

Stage 2 — Construction and pre-functional readiness

Review installation against approved documents. Track inspection, cleanliness, flushing/water-treatment records where applicable, access, identification, sensor/actuator installation and equipment start-up evidence. Resolve readiness items before relying on performance tests.

Stage 3 — Testing and balancing

Establish the agreed operating state. Record air and water distribution measurements, control positions, fan/pump duties and exceptions. Compare measurements with design quantities using the contract’s methods and tolerances; complete retesting after corrections.

Stage 4 — Functional and integrated performance

Use approved scripts for normal modes, transitions, modulation, alarms and relevant interlocks. Verify the real response and recovery rather than a screen indication alone. Safety, smoke-control, electrical and specialist systems require the appropriately competent and authorised parties; do not bypass safeguards to force a result.

Stage 5 — Handover

Link approved results to assets, final settings, drawings, controls descriptions, trend evidence, open defects and retest dates. Provide useful O&M information and operator training. Record what was deferred and who accepts the remaining actions.

Stage 6 — Warranty, seasonal and in-use follow-up

Revisit conditions not available at initial testing. Review comfort, energy use, trends and changes in occupancy or schedules. Existing-building commissioning may investigate previously untested systems; building tuning needs a measured baseline and follow-up to demonstrate persistence.

Process framework: US Department of Energy: Commissioning Process. In-use investigation: Natural Resources Canada: Existing-building commissioning phases. Detailed project methods: CIBSE: Commissioning Codes, using the contractually applicable documents.

A useful commissioning record can be repeated.

Identify the test

- Project, system, asset and exact measurement stations.
- Drawing/specification revision and test-script reference.
- Date, time, personnel, witnesses and instrument identification.
- Calibration status, method, units and relevant uncertainty.

Show the result

- Required result, permitted tolerance and its source.
- Actual conditions, configuration and raw readings.
- Calculations, density/fluid assumptions and final settings.
- Pass/fail or deferred status, defects, corrective work and retest.

For a controls test, add initial conditions, stimulus or requested mode, expected sequence, observed sequence, relevant timestamps and evidence files. For air/water balance sheets, retain design and measured flows together so the reviewer can follow the comparison. Keep client information and private records in the protected portal rather than public case-study notes.

Download sample records and checklists

A symptom is a clue, not a diagnosis.

Possible lines of investigation — confirm with measured evidence

Observation	Things to check	Useful comparison
Low air volume at several terminals	Operating mode, verified speed/direction, filters/coils, damper positions, leakage, blocked paths and measurement method.	Fan duty, main-duct traverse, branch totals and component differential pressures at the same operating state.
High fan speed but poor airflow	Unexpected resistance, installation effects, unstable operation or a mismatch between selection and actual assembly.	Actual flow and correctly defined fan pressure against the exact curve at recorded density and speed.
Room pressure is unexpected	Supply/extract/outdoor-air balance, doors, transfer paths, wind and other systems.	Pressure reference, door state and simultaneous flow readings. Room pressure is not the same as fan static pressure.
Hydronic flow appears low	Exact valve characteristic, fluid settings, air or blockage, strainers, valve travel, controls and available differential pressure.	Independent flow evidence, pump curve and pressure profile across the relevant circuit.
Pump noise or fluctuating readings	Instrument behaviour, entrained air, inlet conditions, unstable operation and mechanical condition.	Absolute inlet conditions, fluid temperature, manufacturer limits and competent inspection. Noise alone does not prove cavitation.
Heat transfer is disappointing despite flow	Temperature-sensor accuracy/location, fluid properties, load, coil cleanliness, control sequence and air/water duty alignment.	Simultaneous flow and paired temperatures under a stable measured load; include latent effects where relevant.
Plant hunts or runs out of hours	Sensor scaling, schedules, deadbands, resets, conflicting demands, overrides and actuator response.	Time-aligned command, feedback, temperatures, modes and energy trends.

Use the project’s agreed compliance pathway.

G4 Ventilation concerns ventilation suited to a building’s occupancy and use. Confirm the consent documents, applicable compliance pathway, outdoor-air and extract requirements, and any specialist requirements. A generic ACH or duct-capacity result cannot establish G4 compliance. Read MBIE’s G4 guidance.

H1 Energy efficiency has its own scope, applicable documents and transition provisions. Verify the requirements applying to the project rather than assuming one rule covers every building or consent date. Measured controls performance and commissioning evidence can support the relevant design objectives. Read MBIE’s H1 guidance.

Commissioning records can support the evidence supplied for a Code Compliance Certificate. Commissioning does not itself issue a CCC or replace decisions by the relevant building consent authority. Green Star or NABERSNZ work needs the project’s specific scope and authorised assessment route; a calculator result or this handbook does not establish a rating or accreditation.

Carry the units through the calculation.

Conversions and assumptions

Quantity	Conversion	Note
Air or water volume flow	1 m³/s = 1,000 L/s = 3,600 m³/h	Use the same actual/reference conditions when comparing air flows.
Pressure	1 kPa = 1,000 Pa; 1 bar = 100 kPa	State gauge, absolute or differential as well as units.
Conventional water column	1 mmH_2O = 9.80665 Pa	Conventional unit conversion; actual fluid-head calculations use the fluid density.
Hydraulic head	$\Delta p = \rho g H$	Pressure-only term; include velocity/elevation differences when finding total pump head.
Air changes	ACH = 3,600Q/V, with Q in m³/s and room volume V in m³	Define whether Q is outdoor, supply or extract flow. The values are not interchangeable.
Sensible heat transfer	Duty = $\rho c_p Q \Delta T$	Use c_p in kJ/(kg·K) to obtain kW. Air-side sensible duty excludes latent heat.

Duct capacity at an assumed velocity

A 500 × 300 mm internal duct has area 0.15 m². At an *assumed* 5 m/s mean velocity, Q = 0.75 m³/s = 750 L/s. This is a calculation example, not a recommended velocity for every application.

Air pressure at a fan

With air density 1.2 kg/m³, inlet velocity 4 m/s and outlet velocity 8 m/s, velocity pressures are 9.6 and 38.4 Pa. If static pressures are −100 and +200 Pa, FTP is 328.8 Pa, FSP is 290.4 Pa and static rise is 300 Pa. They are different readings.

Pump pressure difference

At equal station elevations and velocities, suction +120 kPa and discharge +220 kPa give Δp = 100 kPa. At ρ = 1,000 kg/m³, H = 100,000/(1,000 × 9.80665) ≈ 10.20 m. Discharge pressure alone would overstate this head.

Water-side sensible duty

At an assumed ρ = 1,000 kg/m³ and c_p = 4.18 kJ/(kg·K), 0.5 L/s with a 5 K temperature difference transfers approximately 10.45 kW. Check fluid properties and sensor uncertainty before comparing with the design.

These are original worked examples from the stated equations, not manufacturer performance guarantees. The calculator suite lets you change the assumptions.

Go back to the primary reference.

Sources checked on 25 October 2026. Links may change; follow the publisher’s current guidance and the version specified for the project. CIBSE’s public catalogue is a route to the relevant licensed commissioning codes; this page does not reproduce their procedures or tolerances.

1. ASHRAE: Fans, SI chapter
2. AMCA: Straightening Out Fan Curves
3. Greenheck: Vane Axial Application and Design, pressure concepts
4. NASA Glenn: Conservation of Mass
5. KSB Pump Lexicon: Head
6. KSB Pump Lexicon: Pressure
7. KSB Pump Lexicon: NPSH
8. Grundfos NZ: Heating-pump head and building height
9. TSI: Duct traverse application note TSI-106, Rev C
10. ASHRAE: Measurement and Instruments, SI chapter
11. US Department of Energy: Commissioning Process
12. US Department of Energy: HVAC Commissioning
13. Natural Resources Canada: Existing-building commissioning phases
14. CIBSE: Commissioning Codes
15. MBIE Building Performance: G4 Ventilation
16. MBIE Building Performance: H1 Energy efficiency

This guide uses original explanations and examples. No publisher, manufacturer or standards body endorses this site by being referenced.