VAV Fan Power and Energy at Part Flow

Fan pressure and power of a variable-air-volume system at part flow with a duct static-pressure set point, compared with the cube law and constant-volume operation.

Method: ASHRAE Handbook—Fundamentals (2017); ch. 21 and ASHRAE Handbook—HVAC Applications (2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Design air flow	36,000	m³/h
Design fan pressure	1,000.0	Pa
Static pressure set point (fixed part)	250.00	Pa
Overall fan efficiency	65.000	%
Flow fraction	60.000	%
Hours at this flow per year	4,000.0	h

Calculated results

Parameter	Value	Unit
Fan pressure at part flow	520.00	Pa
Fan power at part flow	4.8000	kW
Fan power at design	15.385	kW
Power ratio	31.200	%
Cube-law ratio	21.600	%
Energy saved against constant volume	42,338	kWh

Notes for this case

• System curve Δp = Δp_sp + (Δp_d − Δp_sp)r² with speed control; efficiency held constant (drive and motor losses rise at low load). Resetting the static set point lowers the fixed part and saves more.

Formula and method

$$\Delta p = \Delta p_{sp} + (\Delta p_d - \Delta p_{sp}) r^2, \quad W = \frac{r \dot{V}_d \Delta p}{\eta}$$

Variables

$\dot{V}_d$	Design air flow	m³/s
Δp_d	Design fan pressure	Pa
Δp_{sp}	Static pressure set point (fixed part)	Pa
η	Overall fan efficiency	-
r	Flow fraction	-
t	Hours at this flow per year	s
Δp	Fan pressure at part flow	Pa
W	Fan power at part flow	W
W_d	Fan power at design	W
W/W_d	Power ratio	-
r^3	Cube-law ratio	-
ΔE	Energy saved against constant volume	J

Method and standards

Fan and system curves.

Assumptions and limits

- Fan efficiency is held at its design value at part flow. In practice fan, motor and drive efficiencies fall at low load, so the part-flow power is higher and the saving smaller than shown.
- Constant efficiency; quadratic system curve above the set point.

References

• ASHRAE Handbook—Fundamentals (2017)
• ch. 21 and ASHRAE Handbook—HVAC Applications (2019)
• ch. 42 (fan–system interaction with a fixed static set point)

Report details

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

This calculator online

https://calc.firecad.com/hvac/ducts/vav-fan-energy

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Reopens the calculator with the inputs of this report.