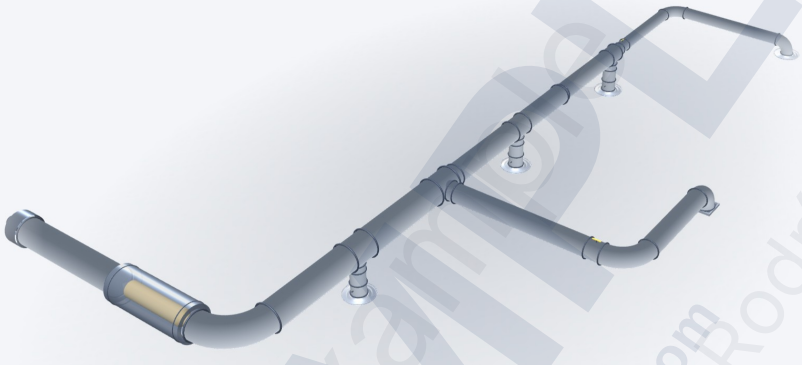
SUPPLY NETWORK · CIRCULAR DUCT

Offices · first floor

Offices · first floor

CLIENT	REFERENCE	PREPARED BY	COMPANY
Example client	EX-001	Raul Rodríguez	Vortia 3D

3D VIEW



The installation meets the calculation criteria
8 of 8 checks passed · details in section 06

FAN AIRFLOW
6,015 m³/h
Network 6,000 + leakage 15 m³/h

TOTAL PRESSURE
107 Pa
Static at the outlet 79 Pa

ELECTRICAL POWER
0.32 kW
Shaft 0.27 kW · motor IEC 0.37 kW

SPECIFIC FAN POWER
193 W/(m³/s)
SFP 0 · limit SFP 4

MAXIMUM VELOCITY
6.8 m/s
Usual ≤ 8 m/s

NETWORK LEAKAGE
0.2 %
Class B · UNE-EN 12237

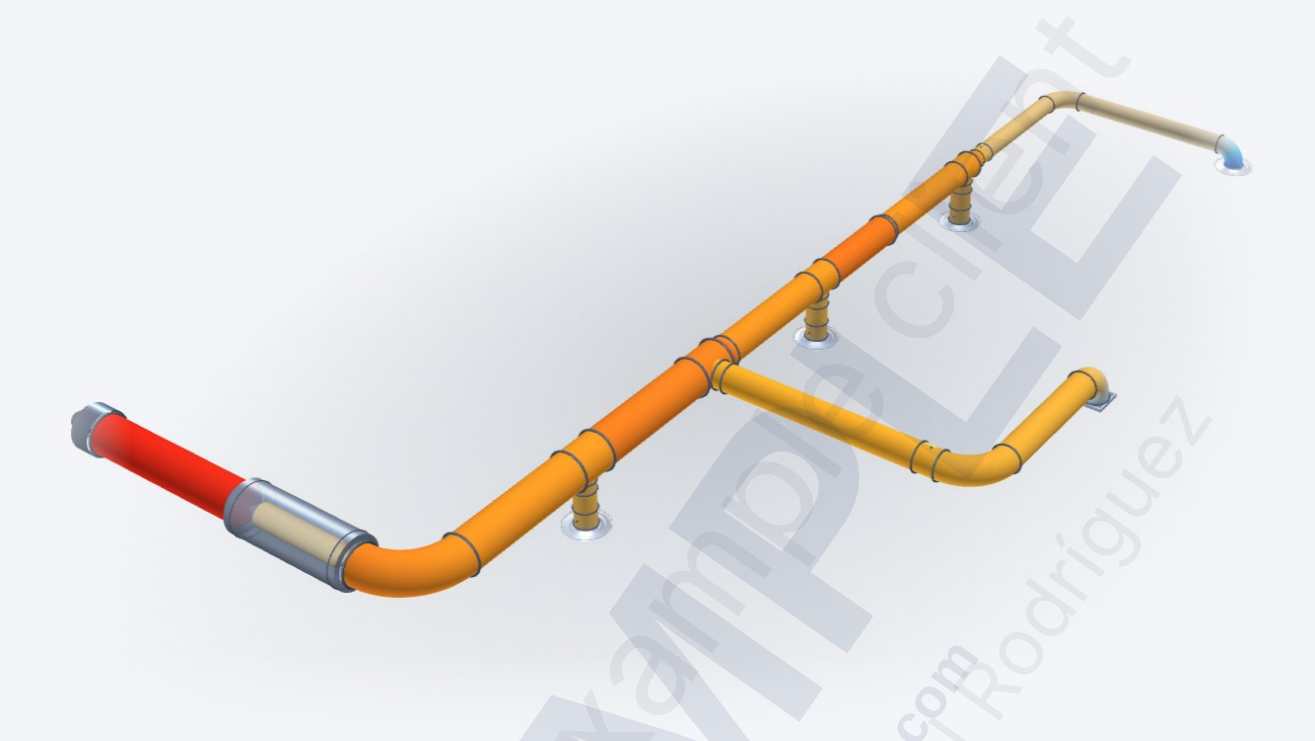
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01 3D views

Network coloured by static pressure relative to atmosphere (red: positive pressure · blue: negative pressure), plus plan and side elevation of the installation.

ISOMETRIC VIEW

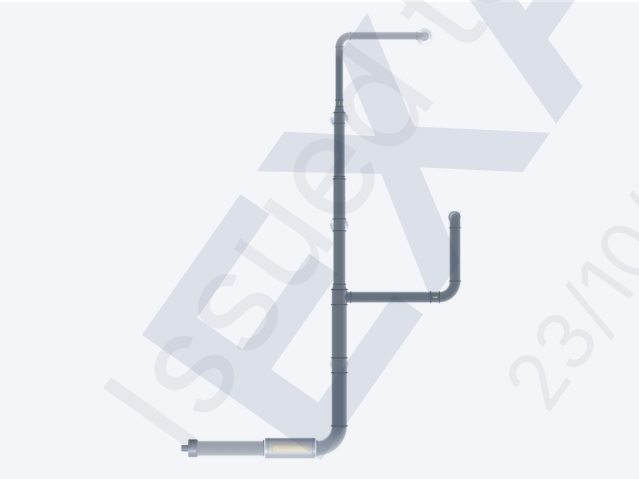


STATIC PRESSURE

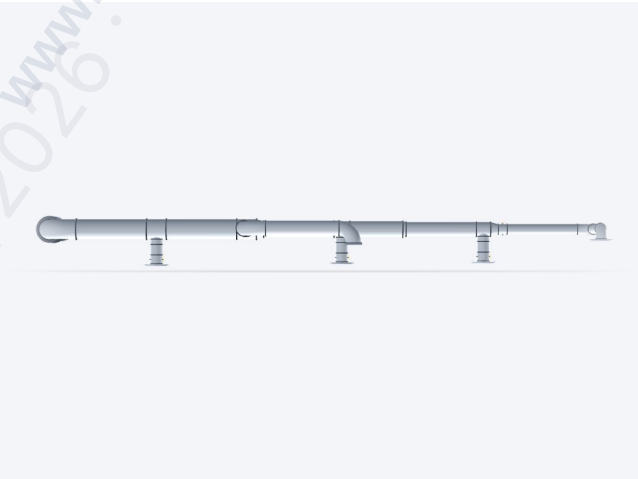


-28 0 +79 Pa

PLAN



SIDE ELEVATION



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02 Design data

NETWORK TYPE
Supply: from the fan to the terminal

NETWORK AIRFLOW
6,000 m³/h

SECTION AT THE FAN
Ø560 mm

AIR
20 °C · altitude 0 m

DENSITY
1.204 kg/m³ · p = 101.33 kPa

KINEMATIC VISCOSITY
1.506·10⁻⁵ m²/s

DUCT
Galvanised sheet steel · ε = 0.090 mm

AIRTIGHTNESS
Class B · UNE-EN 12237

EFFICIENCIES
Fan 65 % · motor 85 %

SYSTEM EFFECT (AMCA 201)
0.00·Pd = 0 Pa

SPECIFIC FAN POWER LIMIT
SFP 4

03 Terminals

Airflow reaching each terminal against its target. The bar shows the calculated airflow and the vertical mark, the target.

TERMINAL	SECTION	AIRFLOW / TARGET	Q M³/H	TARGET	DEV.	V M/S	THROW M	ΔP PA
Diffuser 1	Ø315		1,000	1,000	+0.0 %	3.6	1.8 / 3.7	30.0
Room grille	Ø400		1,494	1,500	-0.4 %	3.3	11.6 / 23.2	41.2
Diffuser 2	Ø315		1,003	1,000	+0.3 %	3.6	1.8 / 3.7	30.2
Diffuser 3	Ø315		1,000	1,000	0.0 %	3.6	1.8 / 3.7	30.0
Diffuser 4	Ø280		1,502	1,500	+0.2 %	6.8	2.2 / 4.5	36.2

Throw: distance at which the jet slows to 0.5 / 0.25 m/s (ASHRAE: x = K·V0·√A0/VT, A0 = airflow / grille effective velocity, K indicative by outlet type).

04 Where is the pressure used?

Run that sets the fan pressure: up to Room grille (17.2 m). It is the run with the least pressure drop across dampers; on the others, the dampers absorb the difference.

107 Pa of fan total pressure



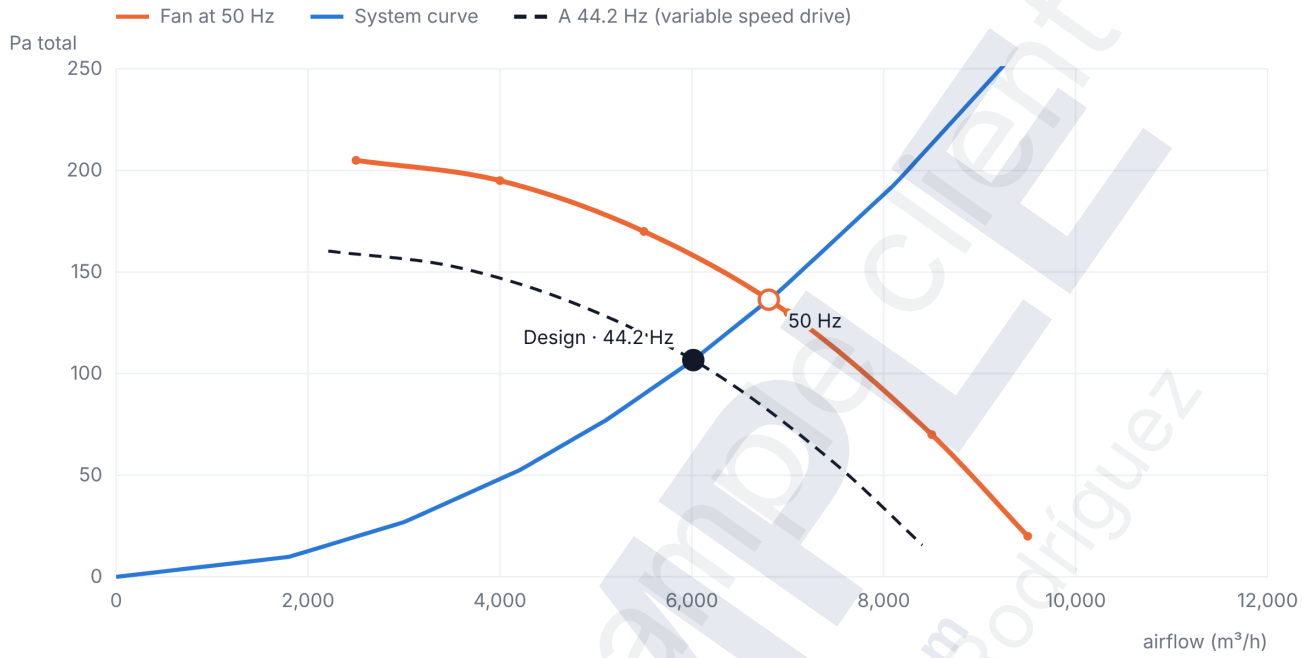
Duct friction	**11 Pa**	10 %	Bends	**5 Pa**	5 %
Tee branches	**26 Pa**	24 %	Balancing dampers	**1 Pa**	1 %
Grilles, diffusers and outlets	**41 Pa**	39 %	Fittings, filters and silencers	**22 Pa**	21 %

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05 Fan and duty point

Catalogue curve of the Example axial fan Ø560 at 50 Hz (total pressure) against the system curve, obtained by recalculating the network at different airflows with the dampers in position. The required frequency comes from the fan laws: airflow varies with rotational speed, pressure with its square and power with its cube.



DESIGN POINT	REQUIRED FREQUENCY	ABSORBED POWER	WITHOUT A DRIVE
6,015 m³/h	**44.2** Hz	**0.36** kW	**6,802** m³/h
107 Pa total pressure	Curve at 50 Hz · max.	From the catalogue	At 50 Hz · 136 Pa

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06 Checks

Criteria from the standards and design guides applied to the calculation results.

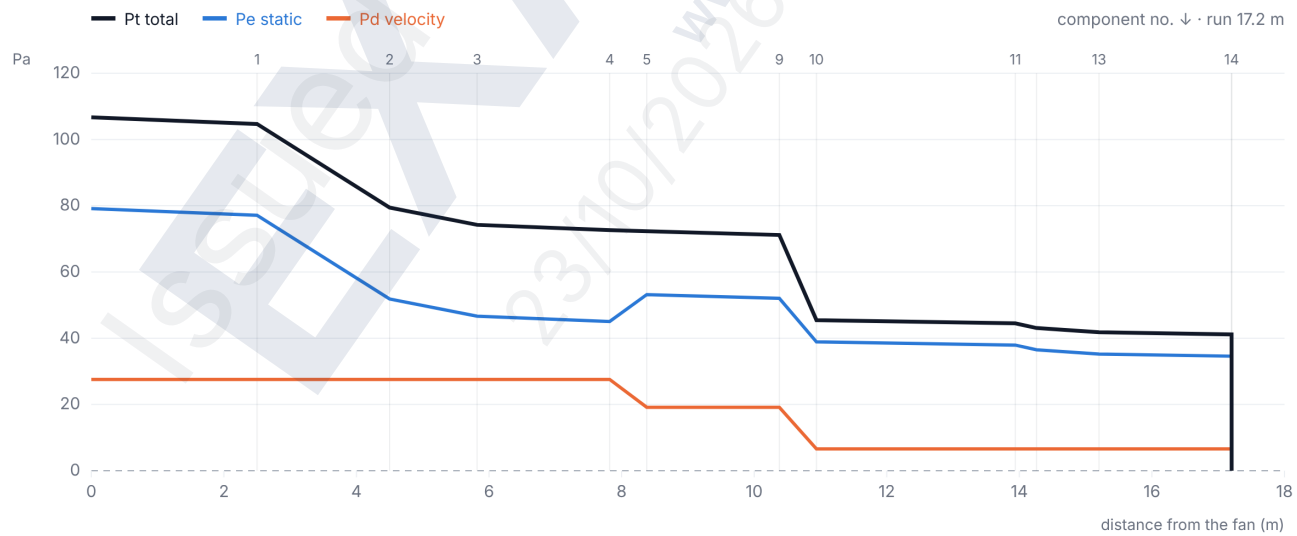
Duct velocity	Maximum 6.8 m/s. Limit 8.0 m/s for non-residential (offices, retail) (Acoustic design practice: mains 5–8 m/s, branches 2.5–4 m/s (ASHRAE Fundamentals)).
Airflow split	Maximum deviation 0.4 % from the target airflow of each terminal. Tolerance ±10 %.
Noise in the rooms (RD 1367/2007)	Worst terminal: 38 dB(A) in offices · office (limit 40 dB(A)). Fan noise through the ducts; the terminals' self-noise is not included.
Fan on its curve	Example axial fan Ø560: design point at 44.2 Hz (curve at 50 Hz, maximum 50 Hz).
Specific fan power (UNE-EN 16798-3)	193 W/(m³/s), category SFP 0. Limit set: SFP 4.
Airtightness (UNE-EN 12237)	Leakage 15 m³/h (0.2 % of the airflow) with Class B in 39.3 m² of duct.
Standard diameters (UNE-EN 1506)	All diameters belong to the R20 series.
Calculation closure	Maximum error of 0.007 Pa between the fan pressure and that required by each terminal.

CALCULATION NOTES

Without a drive, at 50 Hz the fan would give 6,802 m³/h (13 % more than the design). With a drive at 44.2 Hz it is adjusted and energy is saved.

07 Pressure profile

Total, static and velocity pressure along the run to Room grille. The steps correspond to fittings (tees, bends, dampers, transitions and terminals); the numbers at the top are the components in section 10.



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08 Noise in the rooms

Fan noise (79.9 dB(A) sound power, empirical estimate) reaching each room through the ducts, in octave bands (ASHRAE), against the limits of RD 1367/2007, table B2 (Spanish noise regulation; CTE DB-HR, RITE).

TERMINAL	ROOM	LIMIT	LP DB(A)	NR	MARGIN	63	125	250	500	1K	2K	4K	8K
Diffuser 1	Offices · office	40	38	44	+2	47	49	40	30	27	25	25	32
Room grille	Offices · office	40	38	41	+2	50	51	40	28	25	23	22	30
Diffuser 2	Offices · office	40	38	43	+2	47	48	40	29	26	25	24	31
Diffuser 3	Offices · office	40	37	43	+3	47	48	39	29	26	24	23	31
Diffuser 4	Offices · office	40	37	40	+3	47	49	39	28	24	22	21	29

Lp: sound pressure level in the room at the typical listener distance, with direct and reverberant field (Sabine). Fan noise transmitted through the ducts; for terminals chosen from the generic catalogue their self-noise is also added (indicative). For the others, the self-noise of grilles and diffusers must be added (manufacturer's catalogue). n: night-time limit.

09 Energy use and running costs

Fan 3,000 hours a year at the design airflow, electricity at 0.180 €/kWh and 0.331 kg CO_2/kWh. Compared with the same network one size larger and one size smaller in every section.

ALTERNATIVE	PRESSURE PA	POWER KW	KWH/YEAR	€/YEAR	T CO_2/YEAR	MATERIALS €	TOTAL 15 YEARS €
Calculated design	107	0.32	968	174	0.32	1,051*	3,664
One size larger	78	0.24	710	128	0.24	1,180*	3,097
One size smaller	152	0.46	1,376	248	0.46	936*	4,650

"One size larger" reduces the total cost by 567 € in 15 years. Materials at the user's price list; * duct lines without a price estimated at 35 €/m² of sheet metal. Costs not discounted and without electricity price rises. The alternatives are not rebalanced.

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10 Component details

Pt: total pressure · Pe: static pressure · Pd: velocity pressure, relative to atmosphere. “Start” and “end” are the ends of the component in the fan → terminal direction. For tees: straight run / branch.

#	COMPONENT	DETAIL	SECTION MM	Q M³/H	V M/S	PD PA	C	FRICTION PA	LOCAL PA	ΔP PA	PT START	PT END	PE END	LEAKAGE L/S
1	**Straight run**	2.50 m	Ø560	6,000	6.8	27.6	—	2.0	0.0	2.0	106.7	104.7	77.1	0.67
2	**Silencer**	Silencer with pod · 2.0 m · absorbent 50 mm · −25/26/26 dB at 500/1k/2k Hz	Ø560	6,000	6.8	27.6	0.800	3.2	22.1	25.3	104.7	79.4	51.9	0.00
3	**Bend**	90° left, R/D 1.50	Ø560	6,000	6.8	27.6	0.150	1.1	4.1	5.2	79.4	74.2	46.7	0.26
4	**Straight run**	2.00 m	Ø560	6,000	6.8	27.6	—	1.6	0.0	1.6	74.2	72.6	45.1	0.38
5	**90° tee branch**	90° tee branch · Ø315 down · straight 5,000 / branch 1,000 m³/h	Ø560	6,000	6.8→5.6	27.6	0.01 / 1.28	0.0	0.3	0.3 / 35.2	72.6	72.3	53.2	0.11
6	**Straight run**	0.30 m	Ø315	1,000	3.6	7.7	—	0.1	0.0	0.1	37.4	37.3	29.6	0.02
7	**Damper**	closure 15.5°	Ø315	1,000	3.6	7.7	0.931	0.1	7.1	7.2	37.3	30.0	22.4	0.02
8	**Grille / diffuser**	Diffuser 1 · Circular diffuser · 30 Pa at 1,000 m³/h	Ø315	1,000	3.6	7.7	—	—	—	30.0	30.0	0.0	0.0	—
9	**Straight run**	2.00 m	Ø560	5,000	5.6	19.1	—	1.1	0.0	1.1	72.3	71.2	52.0	0.42
10	**90° tee branch**	90° tee branch · Ø400 right · straight 3,505 / branch 1,494 m³/h	Ø560	5,000	5.6→4.0	19.1	0.04 / 1.34	0.0	0.7	0.7 / 25.7	71.2	70.5	61.1	0.12
11	**Straight run**	3.00 m	Ø400	1,494	3.3	6.6	—	1.0	0.0	1.0	45.5	44.5	37.9	0.36
12	**Damper**	closure 0°	Ø400	1,494	3.3	6.6	0.200	0.1	1.3	1.4	44.5	43.1	36.5	0.04
13	**Bend**	90° left, R/D 1.50	Ø400	1,494	3.3	6.6	0.150	0.3	1.0	1.3	43.1	41.8	35.2	0.11
14	**Straight run**	2.00 m	Ø400	1,494	3.3	6.6	—	0.6	0.0	0.6	41.8	41.2	34.6	0.23
15	**Grille / diffuser**	Room grille · Straight blades · 40 Pa at 1,500 m³/h	Ø400	1,494	3.3	6.6	—	—	—	41.2	41.2	0.0	0.0	—
16	**Reducer / expansion**	Ø560→Ø450, 30°	Ø560→Ø450	3,505	4.0→6.1	9.4	0.050	0.1	1.1	1.2	70.5	69.3	46.7	0.04
17	**Straight run**	2.00 m	Ø450	3,505	6.1	22.6	—	1.7	0.0	1.7	69.3	67.5	45.0	0.31
18	**90° tee branch**	90° tee branch · Ø315 down · straight 2,502 /	Ø450	3,505	6.1→4.4	22.6	0.03 /	0.0	0.7	0.7 /	67.5	66.8	55.3	0.07

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#	COMPONENT	DETAIL	SECTION MM	Q M³/H	V M/S	PD PA	C	FRICTION PA	LOCAL PA	ΔP PA	PT START	PT END	PE END	LEAKAGE L/S
		branch 1,003 m³/h					1.34			30.3				
19	**Straight run**	0.30 m	Ø315	1,003	3.6	7.7	—	0.1	0.0	0.1	37.3	37.1	29.4	0.02
20	**Damper**	closure 15°	Ø315	1,003	3.6	7.7	0.883	0.1	6.8	6.9	37.1	30.2	22.5	0.02
21	**Grille / diffuser**	Diffuser 2 · Circular diffuser · 30 Pa at 1,000 m³/h	Ø315	1,003	3.6	7.7	—	—	—	30.2	30.2	0.0	0.0	—
22	**Straight run**	1.50 m	Ø450	2,502	4.4	11.5	—	0.7	0.0	0.7	66.8	66.1	54.6	0.26
23	**Reducer / expansion**	Ø450→Ø400, 30°	Ø450→Ø400	2,502	4.4→5.5	11.5	0.050	0.1	0.9	1.0	66.1	65.1	46.7	0.01
24	**Straight run**	2.00 m	Ø400	2,502	5.5	18.4	—	1.7	0.0	1.7	65.1	63.5	45.0	0.27
25	**90° tee branch**	90° tee branch · Ø315 down · straight 1,502 / branch 1,000 m³/h	Ø400	2,502	5.5→3.3	18.4	0.06 / 1.42	0.0	1.2	1.2 / 26.1	63.5	62.3	55.6	0.06
26	**Straight run**	0.30 m	Ø315	1,000	3.6	7.6	—	0.1	0.0	0.1	37.4	37.2	29.6	0.02
27	**Damper**	closure 15.5°	Ø315	1,000	3.6	7.6	0.931	0.1	7.1	7.2	37.2	30.0	22.3	0.02
28	**Grille / diffuser**	Diffuser 3 · Circular diffuser · 30 Pa at 1,000 m³/h	Ø315	1,000	3.6	7.6	—	—	—	30.0	30.0	0.0	0.0	—
29	**Reducer / expansion**	Ø400→Ø280, 30°	Ø400→Ø280	1,502	3.3→6.8	6.6	0.050	0.2	1.4	1.5	62.3	60.7	33.1	0.03
30	**Damper**	closure 6.5°	Ø280	1,502	6.8	27.7	0.372	0.5	10.3	10.8	60.7	50.0	22.3	0.02
31	**Straight run**	2.00 m	Ø280	1,502	6.8	27.7	—	3.7	0.0	3.7	50.0	46.2	18.6	0.11
32	**Bend**	90° right, R/D 1.50	Ø280	1,502	6.8	27.7	0.150	1.2	4.1	5.4	46.2	40.9	13.2	0.03
33	**Straight run**	2.50 m	Ø280	1,502	6.8	27.7	—	4.7	0.0	4.7	40.9	36.2	8.5	0.09
34	**Grille / diffuser**	Diffuser 4 · Circular diffuser · 30 Pa at 1,500 m³/h	Ø280	1,502	6.8	27.7	—	—	—	36.2	36.2	0.0	0.0	—

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11 Bill of materials

Network quantities: 22.4 m of straight duct, 30.0 m² of sheet metal (≈ 159 kg with indicative thicknesses). Bends, reducers and branches are counted as fittings.

DESCRIPTION	QUANTITY	UNIT
DUCT		
Galvanised sheet steel Ø280 · e 0.60 mm	4.5	m
Galvanised sheet steel Ø315 · e 0.60 mm	0.9	m
Galvanised sheet steel Ø400 · e 0.60 mm	7.0	m
Galvanised sheet steel Ø450 · e 0.60 mm	3.5	m
Galvanised sheet steel Ø560 · e 0.80 mm	6.5	m
SPECIAL FITTINGS		
Bend 90° Ø560 · R/D 1.50	1	no.
90° tee branch Ø560 / Ø315	1	no.
90° tee branch Ø560 / Ø400	1	no.
Bend 90° Ø400 · R/D 1.50	1	no.
Bend 90° Ø400 · R/D 1.00	1	no.
Reducer Ø560 → Ø450 · 30°	1	no.
90° tee branch Ø450 / Ø315	1	no.
Reducer Ø450 → Ø400 · 30°	1	no.
90° tee branch Ø400 / Ø315	1	no.
Reducer Ø400 → Ø280 · 30°	1	no.
Bend 90° Ø280 · R/D 1.50	1	no.
Bend 90° Ø280 · R/D 1.00	1	no.
CONTROL		
Balancing damper butterfly Ø315	3	no.
Balancing damper butterfly Ø400	1	no.
Balancing damper butterfly Ø280	1	no.
CLEANING AND INSPECTION		
Cleaning and inspection access door for duct Ø560 (UNE-EN 12097)	1	no.
Cleaning and inspection access door for duct Ø315 (UNE-EN 12097)	3	no.
Cleaning and inspection access door for duct Ø400 (UNE-EN 12097)	1	no.
Cleaning and inspection access door for duct Ø280 (UNE-EN 12097)	1	no.
EQUIPMENT AND FITTINGS		
Silencer with pod Ø560 · 2.0 m · absorbent 50 mm	1	no.

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DESCRIPTION	QUANTITY	UNIT
TERMINALS		
Circular diffuser · 1,000 m³/h · connection Ø315	3	no.
Straight-blade grille · 1,500 m³/h · connection Ø400	1	no.
Circular diffuser · 1,500 m³/h · connection Ø280	1	no.
INSTALLATION		
Support / clamp (indicative, 1 every 3 m)	8	no.

12 Regulations and calculation method

REFERENCE	APPLICATION IN THIS CALCULATION
ASHRAE Handbook — Fundamentals, ch. 21 "Duct Design"	Darcy-Weisbach with the Colebrook-White friction factor, standard air (1.204 kg/m³), roughness values and fitting coefficients: smooth-radius bends CD3-1 (C at 90° by R/D × angle factor) and butterfly damper CD9-1.
I. E. Idelchik — Handbook of Hydraulic Resistance	Diverging (supply) and converging (extract) tees based on the velocity pressure of the common duct; sudden contraction ζ = 0.5·(1 − A_2/A_1)^0.75. Expansions per Gibson: ΔPt = ψ(θ)·½ρ(v_1 − v_2)²; at 180°, Borda-Carnot.
ACGIH — Industrial Ventilation, Manual of Recommended Practice for Design	Hood entry loss (C·Pd of the duct) and minimum transport velocities according to the contaminant.
UNE-EN 12237 · UNE-EN 1507	Airtightness classes A–D: leakage f = c·p^0.65 l/(s·m²) with the mean static pressure of each component.
UNE-EN 1506 · UNE-EN 1505	Series of standard circular duct diameters (R20) and rectangular sheet metal duct sizes.
Rectangular duct (ASHRAE)	Velocity and velocity pressure with the actual area a·b; friction with the hydraulic diameter Dh = 2ab/(a + b). Fittings with the circular coefficients of equal area and r/W for bends (approximation).
UNE-EN 16798-3	Specific fan power SFP = electrical power / fan airflow and its category (SFP 0 to SFP 7).
ISO 5801 · AMCA 201	Fan total pressure (total pressure difference between outlet and inlet) and system effect as a coefficient on the velocity pressure at the fan opening.
ISA standard atmosphere	p = 101,325·(1 − 2.25577·10⁻⁵·h)^5.25588; density from the ideal gas law and viscosity from Sutherland.
CTE DB-HS 3 (Spanish Building Code: indoor air quality)	Section 4.2.2, formula 4.1: extract duct section S ≥ 2.50·qvt (cm², l/s) next to habitable rooms, equivalent to v ≤ 4 m/s; on the roof S ≥ 1.50·qvt. Applied as a velocity limit for residential use.
AMCA 201 · system effect	Effective length of straight duct at the fan outlet: 2.5 D up to 12.7 m/s plus 1 D for every additional 5.08 m/s.
ASHRAE — Space Air Diffusion	Supply jets: Vx/V0 = K·√A0/x; throw at terminal velocity VT: x = K·V0·√A0/VT.
ACGIH — capture (Dalla Valle)	Plain opening Q = Vc·(10x² + A); flanged Q = 0.75·Vc·(10x² + A); valid up to x ≈ 1.5 D.
RITE (RD 1027/2007)	Framework for thermal installations in buildings (Spanish RITE). The report provides airtightness and specific fan power for verification, with the limits set by the user.
RD 1367/2007 · CTE DB-HR · ASHRAE	Installation noise limits in rooms (table B2: bedrooms 35/25 dB(A) day/night, living rooms 40/30, offices 40, private offices and classrooms 35, reading rooms 30). Octave-band propagation: attenuation of ducts and bends, silencers (Sabine: ΔL = 1.05·α^1.4·P/S dB/m, or manufacturer's data), split at branches, end reflection and room correction Lp = Lw + 10·log(Q/(4πr²) + 4/R).

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REFERENCE	APPLICATION IN THIS CALCULATION
Fan laws · ISO 13348	Conversion of the fan curve to another speed: $Q_2 = Q_1 \cdot (n_2/n_1)$, $p_2 = p_1 \cdot (n_2/n_1)^2$, $P_2 = P_1 \cdot (n_2/n_1)^3$. Duty point: intersection of the fan curve with the system curve; fan static pressure = total − Pd at its outlet (ISO 5801).
UNE-EN 12097 · UNE-EN 15780	Cleaning and inspection access doors next to components that need maintenance and on straight runs; cleanliness and hygiene of ductwork systems.
Emission factors (MITECO/IDAE, RITE)	Electricity emissions with the conversion factor given by the user (default 0.331 kg CO_2/kWh, Spanish mainland grid). Consumption = electrical power × operating hours.

PROCEDURE

1. The diameter of each component is assigned.
2. From each terminal towards the fan, the total pressure curve required as a function of airflow is built; at each tee, the split that equalises the total pressure of both branches at the junction is found.
3. With the fan airflow, the network is traversed calculating friction, local losses and pressures for each component.
4. The closure is checked at each terminal (maximum error 0.007 Pa).
5. Leakage, system effect, power and SFP are added.

13 Scope and limitations

- Preliminary sizing and hydraulic check of the network. It does not replace the technical design or site supervision, which are the responsibility of a competent engineer.
- The results depend on the data entered (layout, airflows, catalogue pressure drops of grilles, diffusers, hoods and fittings). Terminals from the Vortia 3D generic catalogue use typical values (effective area, ζ and noise) calibrated against manufacturer's data: for the final installation they must be checked against the catalogue of the model installed. Generic silencers (Sabine attenuation and typical ζ) are for selection and space planning: the final model must provide at least that attenuation per band with its catalogue ΔP. ACGIH hood coefficients are indicative: if the manufacturer provides its own, that one must be used.
- One-dimensional model by runs, incompressible and steady flow. The 3D view is illustrative; it is not a computational fluid dynamics (CFD) calculation.
- It does not include the mechanical strength or the support of the ductwork.
- Fire protection: the network has no fire dampers. If it passes through elements separating fire compartments, they must be fitted or ducts with the same fire resistance must be used (CTE DB-SI 1, section 3).
- Cleaning and inspection: 6 access doors indicative per UNE-EN 12097 (EN 12097) (next to dampers, fire dampers, silencers and fittings, and on straight runs). Cleanliness and hygiene are checked per UNE-EN 15780 (EN 15780).
- The bill of materials is a take-off of the calculated network; thicknesses, weights and supports are indicative and must be confirmed with the duct manufacturer.

PREPARED BY

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REVIEWED / APPROVED

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EXAMPLE
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