## Fabric Duct vs Metal Duct: Energy Savings

FabricAir R&D

## 1. System pressure loss comparison

The comparison is based on industrial application example; room size is 25 x 25 m, which in total requires even air distribution across 625 $m^2$ in the working area (1,8 m above floor). Ventilation system is installed in the middle of the room 7 m above floor. The total airflow is 8000 $m^3/h$.

1.1 Conventional metal ductwork system

The system is made out of widely used corrugated galvanized spiral ducts. It contains 4 industrial swirl diffusers spread across the room ceiling, each supplying 2000 $m^3/h$ (Figure 1). Diffusers are equipped with adjustable blades, which are set to 45˚ angle to guide the air towards the working space. According to manufacturer's data, with this configuration one diffuser supply the air 5 m in radius with throw length to the working area. Complete calculation of system's pressure loss was carried out, and the results are listed in Table 1.

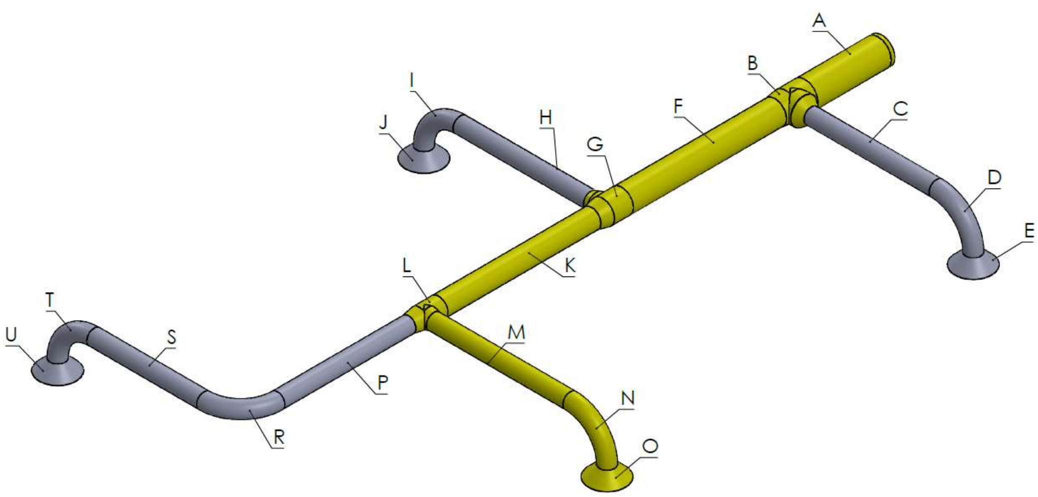


Figure 1: Metal ductwork system.

Table 1: System's dimensions and pressure loss calculation.

| ID | Type | Airflow [m3/h] | Diameter [mm] | Velocity [m/s] | Linear friction loss [Pa] | Length [m] | Friction loss [Pa] | Direction | Fitting loss coefficient* | Fitting loss [Pa] |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Duct | 8000 | 710 | 5,6 | 0,55 | 2,5 | 1,4 | | | |
| B | Tee | | | | | | | A-F<br>A-C | 0,13<br>1,8 | 2,5<br>34 |
| C | Branch | 2000 | 400 | 4,4 | 0,7 | 5 | 3,5 | | | |
| D | Bend 90° | | | | | | | C-E | 0,25 | 2,9 |
| E | Diffuser | | | | | | | | | 80** |
| F | Duct | 6000 | 630 | 5,3 | 0,58 | 5 | 2,9 | | | |
| G | Tee | | | | | | | F-K<br>F-H | 0,14<br>1,94 | 2,4<br>33,3 |
| H | Branch | 2000 | 400 | 4,4 | 0,7 | 5 | 3,5 | | | |
| I | Bend 90° | | | | | | | H-J | 0,25 | 2,9 |
| J | Diffuser | | | | | | | | | 80** |
| K | Duct | 4000 | 500 | 5,7 | 0,86 | 5 | 4,3 | | | |
| L | Tee | | | | | | | K-P<br>K-M | 0,14<br>1,87 | 2,7<br>35,9 |
| M | Branch | 2000 | 400 | 4,4 | 0,7 | 5 | 3,5 | | | |
| N | Bend 90° | | | | | | | M-O | 0,25 | 2,9 |
| O | Diffuser | | | | | | | | | 80** |
| P | Branch | 2000 | 400 | 4,4 | 0,7 | 5 | 3,5 | | | |
| R | Bend 90° | | | | | | | P-S | 0,25 | 2,9 |
| S | Branch | 2000 | 400 | 4,4 | 0,7 | 5 | 3,5 | | | |
| T | Bend 90° | | | | | | | S-U | 0,25 | 2,9 |
| U | Diffuser | | | | | | | | | 80** |

* Determined from ASHRAE Duct Fitting Database
** Manufacturer's data

Determination of system's critical path:
Run A-E: A + B + C + D + E = 121,8 Pa
Run A-J: A + B + F + G + H + I + J = 126,5 Pa
Run A-O: A + B + F + G + K + L + M + N + O = 135,8 Pa
Run A-U: A + B + F + G + K + L + P + R + S + T + U = 109,0 Pa

Calculations show that system's critical path is A–O (indicated in yellow in Figure 1) with the highest total pressure loss of 135,8 Pa. Theoretically, to balance the system regulating dampers should be used on the remaining branches. In practice - as suggested by ASHRAE Fundamentals Handbook – due to accuracy limitations of fitting data (loss coefficients) and effects of close-coupled fittings, dampers for each branch throughout the system should be provided.

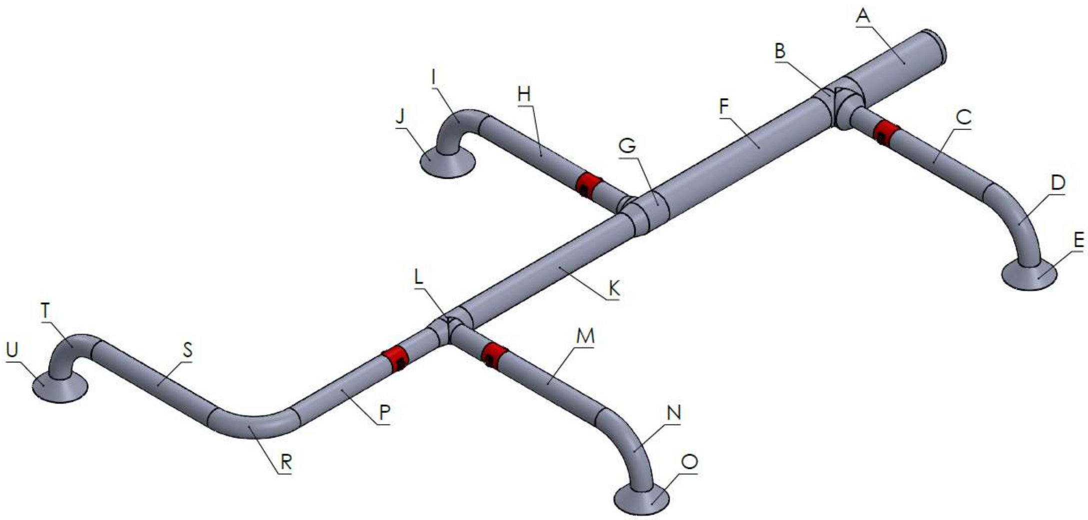


Figure 2: Balanced metal sheet ventilation system with regulating dampers (indicated in red).

According to manufacturer's data, regulating damper (66% open) on L-O branch creates pressure loss of 25 Pa. Balanced metal sheet ventilation system's total pressure loss becomes equal to 135,8 + 25 = 160,8 Pa.

## 1.2 Fabric air dispersion system

Fabric duct embodies complete freedom and flexibility to locate flow models (perforations) at any location along the circumference of the duct and with the exact size (hole diameter) needed. With this feature it only requires one straight duct in the centre of the considered room to distribute air across the entire space at acceptable air velocity in the working area. Duct is with diameter Ø710 and 20 m long. It is designed for 120 Pa static pressure inside the duct (FabricAir standard). Lines of hole perforations are located at 4, 5, 6, 7 and 8 o'clock positions and hole sizes are adjusted accordingly to reach the desired air distribution.

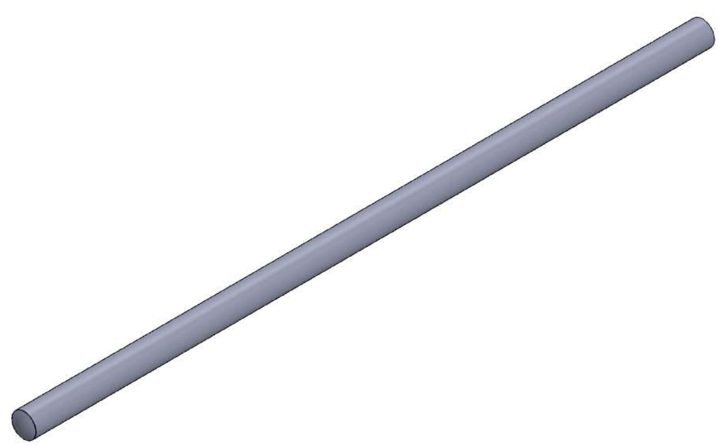

Figure 3: Fabric air dispersion system.

The air is dispersed continuously along the entire length from constant diameter fabric duct, so velocity inside the duct gradually decreases. This means that the friction loss decreases along the length, so the total friction loss in the fabric duct is very small. This also means that static pressure will be slightly smaller in the beginning of the duct and will increase along the length of the duct due to static regain. Pressure loss analysis in Figure 4 show that the total pressure loss of this fabric duct is 128,5 Pa.

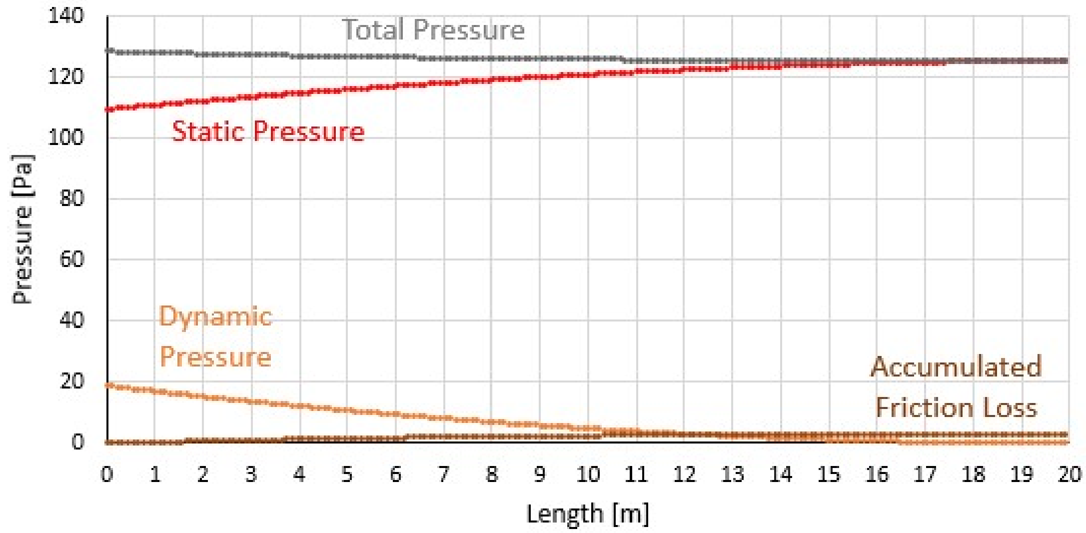


Figure 4: Fabric duct pressure loss analysis at design static pressure 120 Pa.

It is possible to reduce the pressure drop by designing the duct at lower static pressure inside the duct. In this case, if the fabric duct is designed at 100 Pa static pressure, the total pressure loss decreases to 110,8 Pa (Figure 5). To obtain the same air distribution this will simply require slight increase in perforation hole sizes.

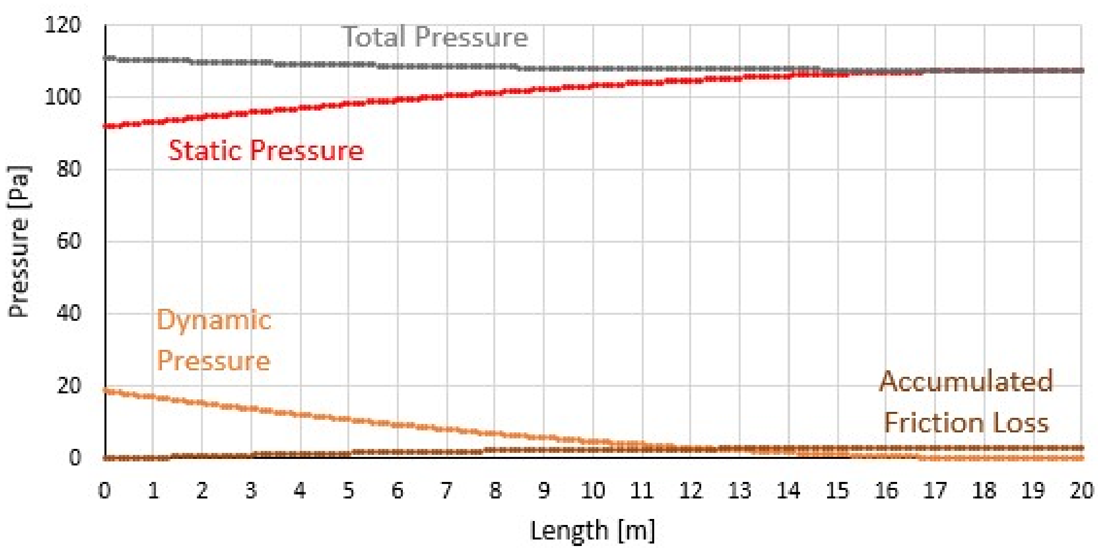


Figure 5: Fabric duct pressure loss analysis at design static pressure 100 Pa.

1.3 Comparison

Total pressure loss of metal ductwork system: 160,8 Pa

Total pressure loss of fabric air dispersion system ($P_{s,design}$ = 120 Pa): 128,5 Pa

Total pressure loss of fabric air dispersion system ($P_{s,design}$ = 100 Pa): 110,8 Pa

For comparison we assume the same fan for all systems. Assumed fan working parameters for metal duct system: airflow 8000 $m^3/h$, pressure 160,8 Pa, rotation frequency 50 Hz, power consumption 4,9 kW.

Using the Second Fan Law and the Third Fan Law, we find the fan working parameters in the case of fabric air dispersion systems.

Table 2: Fan working parameters at the different ventilation systems.

| System | Rotation frequency [Hz] | Pressure [Pa] | Power [kW] |
|---|---|---|---|
| Metal | 50,0 | 160,8 | 4,9 |
| Fabric (120 Pa) | 44,7 | 128,5 | 3,5 |
| Fabric (100 Pa) | 41,5 | 110,8 | 2,8 |

**Due to lower pressure drop when using fabric air dispersion system, the energy consumption is from 28,6 up to 42,8 % less compared to metal ductwork system.**

## 2. Thermal comparison

The difference in air distribution principles between conventional metal diffusers and fabric air dispersion systems can lead to significant energy savings when fabric ducts are used. The main difference is that with fabric ducts the air is supplied in the room through much greater surface area, leading to more even and more efficient air distribution. A comprehensive study [1] has been carried out to compare the thermal (heating) performance of conventional ductwork with fabric-based ductwork at different flow rates. The study shows that fabric ducts heat the room faster, more uniformly, and more efficient. For the metal diffuser system, a significant fraction of air brought into the room stayed along the ceiling, causing large amounts of energy to escape out the outlet. On the contrary, the higher air speeds and the multiple inlets of the fabric system resulted in more energy being absorbed by the room. **The fabric air dispersion system was determined to be 24,5 % more efficient than the ceiling metal diffuser system.**

[1] A. Fontanini, M. G. Olsen, B. Ganapathysubramanian, Thermal comparison between ceiling diffusers and fabric ductwork diffusers for green buildings, *Department of Mechanical Engineering, 2100 Black Engineering, Iowa State University, Ames, IA 50010, USA.*

## 3. Conclusions

Combining the positive effects on energy consumption in terms of pressure drop and thermal performance, fabric air dispersion systems can lead to more than 40% energy savings compared to conventional metal ductwork systems.