BMAC Europe
COMMERCIAL HEATING | AIR HANDLING UNIT FILTERS

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Project: Data Centre Marketing Innovative

Subject: Air Handling Unit – Filter Performance Analysis

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MVEE-F7 vs MPG-7 for Data Centre.

The following is an analysis of the possible Electrical, Cost and Carbon Savings involved with using filters of superior energy efficiency in a ventilation system according to Eurovent 4/24 - 2023 "Energy Consumption Evaluation of Air Filters for General Ventilation Purposes".

https://eurovent.eu/?q=content/eurovent-424-2023-energy-consumption-evaluation-air-filters-general-ventilation-purposes

The analysis will investigate the savings involved in using the MVEE-F7-03 rather than MPG-7-08635-03G for a sample facility with:

- 66 x Air Handling Units (AHU)
- 24 x F7 Bag Filter per AHU
- 18.5 m^3/s Volume Flow Rate supplied by each AHU.

Using Eurovents 4/24 evaluation we can use the integral average pressure expected over the filters lifetime to calculate the energy consumption directly related to the filters pressure drop by adjusting the parameters as to represent a Data Centre (DC) ventilation system rather than a general ventilation system.

The energy consumption of air filters can be determined as a function of the volume flow rate, the fan efficiency, the operation time, and the average pressure drop. Due to dust loading during operation the pressure drop of a filter is exponentially increasing. The related energy consumption during a certain period can be calculated from the integral average of the pressure drop over this period.

The aim of the Eurovent 4-24 document is to assess the average yearly energy consumption based on laboratory test procedure, which can be the basis to give the user of an air filter an in-depth guidance for filter selection.

The portion of the total yearly energy consumption which is related to the filters pressure drop can be calculated using Eq. (1):

$$W = \frac{q_v \cdot \overline{\Delta P} \cdot t}{\eta \cdot 1000} \qquad (1)$$

Where: q_v = 18.5 m^3/s, t = 8760h and η = 0.80

These parameters are based on a sample facility, operation time is assumed as one year, and fan efficiency is estimated at 80%

To account for a variance in fan speeds and cooling demand, a Cooling Demand Variance Factor (CDVF) of 80% will be introduced.

In the case filters are changed according to a fixed time schedule, the operating time of the filters is known, and the pressure drop curve and Final Pressure Drop (FPD) must be determined to calculate the average pressure drop. As a laboratory test method, the average pressure is determined from a loading of the filter according to ISO 16890-3 using synthetic test dust specified in ISO 15957 as L2 (AC Fine)

The average pressure drop can be calculated with this method:

1. Carry put full test in accordance with ISO 16890 at nominal flow rate and determine ePMx efficiencies and the ISO ePMx group (in this case –VTT testing & ISO ePM1 60%)
2. Load the filter with ISO L2 dust according to the procedure in ISO 16890-3, **feeding the total amount of dust given in table 1** or to the final pressure drop (300 Pa), whichever comes first.
3. During dust loading the pressure drop curve versus dust fed shall be recorded with **at least nine data points** including the initial data point. For the last loading step, the total amount of dust fed in (n>=8) shall be equal or slightly larger than the amount of dust given in Table 1. Additional dust loading increments should give smooth curve pressure drop versus dust fed.

ISO group	ISO *e*PM$_1$	ISO *e*PM$_{2,5}$	ISO *e*PM$_{10}$
Amount of dust fed M_x for the flow rate q_V (m^3/s)*	$\frac{q_V}{0.944} \cdot 200$ g	$\frac{q_V}{0.944} \cdot 250$ g	$\frac{q_V}{0.944} \cdot 400$ g

Table 1: Dust amount used for Eq. (2)

As the ISO class group of filters used in the sample DC is **ISO ePM1**, the value used for Mx will be as follows:

AHU flow rate - qv = 18.5 m³/s (24 Filters) ***Filter flow rate – qv = 0.77 m³/s***

$$Mx = \frac{0.77}{0.944} \cdot 200g$$

$$\boldsymbol{Mx = 163.3\ g}$$

4. Calculate the average pressure drop by using Eq. (2) from the n+1 data points pressure versus mass of dust fed.

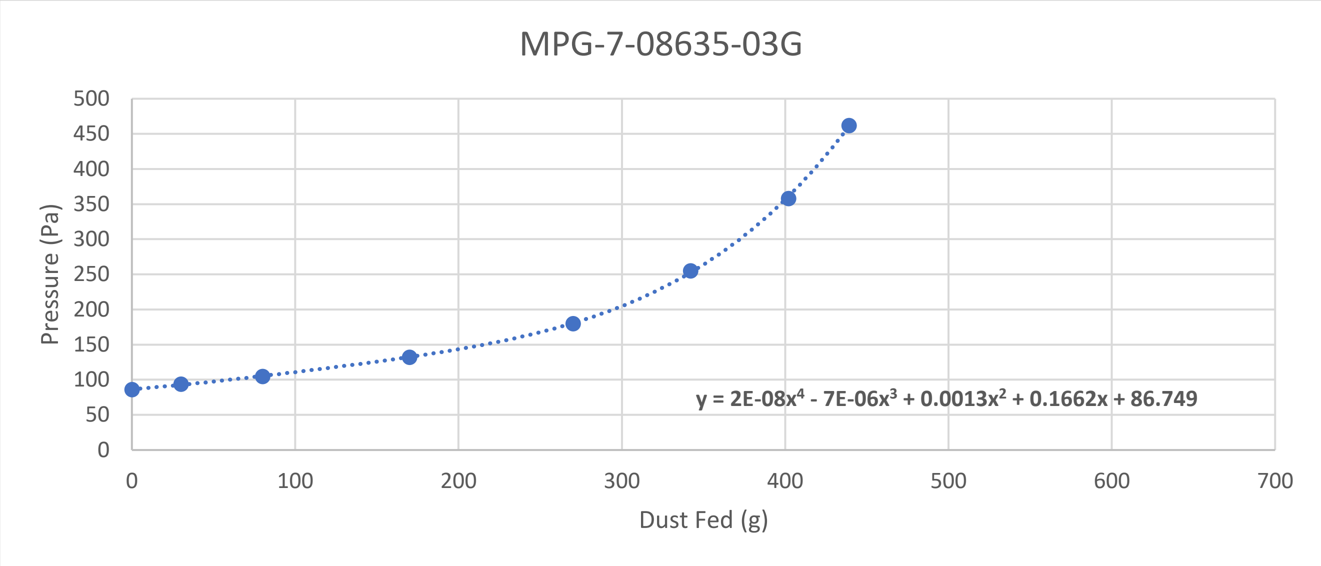
$$\overline{\Delta p} = \frac{1}{M_x} * \sum_{i=1}^{n} \overline{\Delta p_i} * \Delta m_i \qquad (2)$$

Where:

$$\overline{\Delta p_i} = 0.5 \cdot (\Delta p_i + p_{i-1})$$

$$\Delta m_i = m_i - m_{i-1}$$

MPG-7-08635-03G



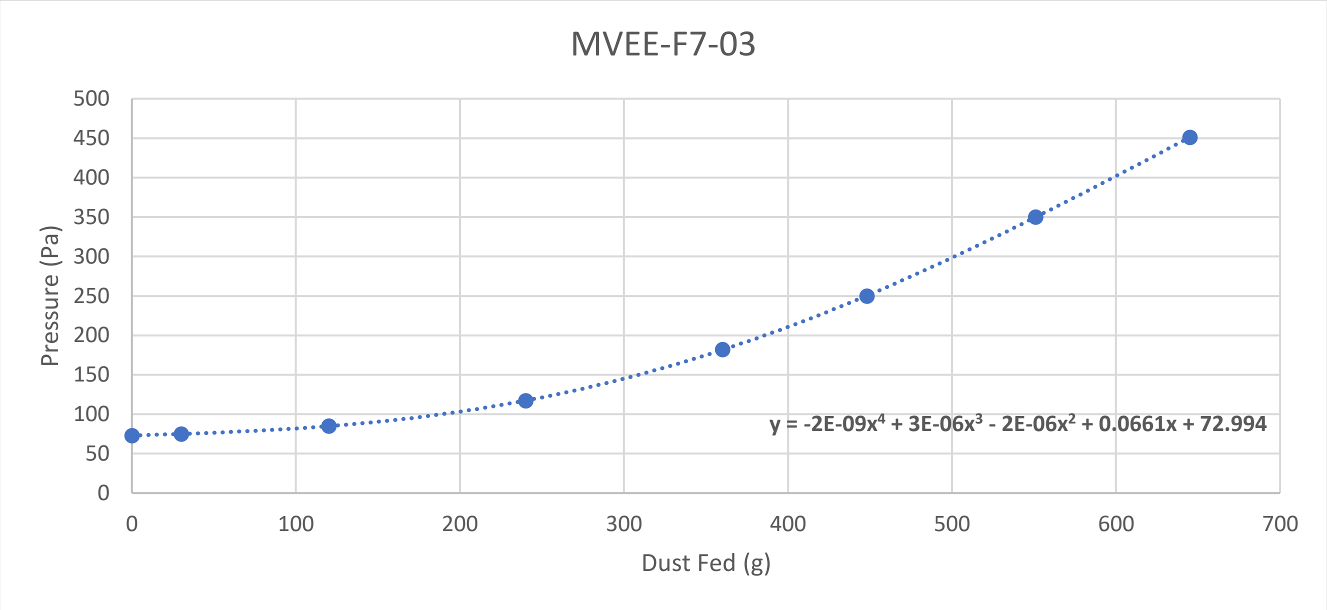
Step	Dust Fed m_i (g)	Pressure Δp_i (Pa)	Dust Increment (Δm_i) (g)	Av Pressure Drop $\overline{\Delta p_i}$	$\overline{\Delta p_i} * \Delta m_i$
0	0	86			
1	30.0	92.0	30.0	89.0	2669.7
2	70.0	102.1	40.0	97.0	3881.3
3	100.0	110.6	30.0	106.4	3190.5
4	150.0	126.7	50.0	118.7	5932.5
5	180.0	138.2	30.0	132.4	3973.3
6	200.0	147.2	20.0	142.7	2854.5
7	230.0	163.8	30.0	155.5	4665.5
8	260.0	185.5	30.0	174.6	5238.8
				SUM	**32406.2**

$$\overline{\Delta p} = \frac{1}{M_x} * \sum_{i=1}^{n} \overline{\Delta p_i} * \Delta m_i$$

$$\overline{\Delta p} = \frac{1}{163.3} * 32406.2$$

$$\boldsymbol{\overline{\Delta p} = 198.44\ Pa}$$

MVEE-F7-03



Step	Dust Fed m_i (g)	Pressure Δp_i (Pa)	Dust Increment (Δm_i) (g)	Av Pressure Drop $\overline{\Delta p_i}$	$\overline{\Delta p_i} * \Delta m_i$
0	0.0	73.0			
1	30.0	75.1	30.0	74.0	2220.9
2	70.0	78.6	40.0	76.8	3073.2
3	100.0	82.4	30.0	80.5	2414.8
4	150.0	92.0	50.0	87.2	4359.3
5	180.0	100.2	30.0	96.1	2883.2
6	200.0	106.9	20.0	103.6	2071.7
7	230.0	119.0	30.0	113.0	3389.1
8	260.0	133.6	30.0	126.3	3789.6
				SUM	**24201.8**

$$\overline{\Delta p} = \frac{1}{M_x} * \sum_{i=1}^{n} \overline{\Delta p_i} * \Delta m_i$$

$$\overline{\Delta p} = \frac{1}{163.3} * 24201.8$$

$$\boldsymbol{\overline{\Delta p} = 148.2\ Pa}$$

Total Yearly Energy Consumption Related to Filters Pressure Drop

Now that an average pressure drop for each filter has been found, the portion of the total yearly energy consumption which is related to the filters pressure drop can be calculated using Eq. (1):

$$W = \frac{q_v \cdot \overline{\Delta P} \cdot t}{\eta \cdot 1000} \quad (1)$$

MPG-7-08635-03G

$$W = \frac{q_v \cdot \overline{\Delta P} \cdot t}{\eta \cdot 1000} \quad (1)$$

Where: q_v = 18.5 m^3/s, $\overline{\Delta P} = 198.4\ Pa$ t = 8760h and η = 80%

$$W = \frac{18.5 \cdot 198.4 \cdot 8760}{0.8 \cdot 1000} x\ 80\%$$

W = 32,153 kWh / AHU

W = 2,122,078 kWh Total

MVEE-F7-03

$$W = \frac{q_v \cdot \overline{\Delta P} \cdot t}{\eta \cdot 1000} \quad (1)$$

Where: q_v = 18.5 m^3/s, $\overline{\Delta P} = 148.2\ Pa$ t = 8760h and η = 80%

$$W = \frac{18.5 \cdot 148.2 \cdot 8760}{0.8 \cdot 1000} x\ 80\%$$

W =24,017 kWh / AHU

W = 1,585,141 kWh Total

Savings

For a facility, equip with sixty-six AHUs, each with twenty-four F7 Bag filters and supplying 18.5 m^3/s to the data halls the following savings are achievable when MPG-7-08635-03G filters are replaced with more efficient and better performing MVEE-F7-03 filters.

Electrical Consumption Savings **537 MWh / Annum**

Electrical Cost Savings:

In the absence of knowing the exact rate paid for electricity per unit we present three possible options.

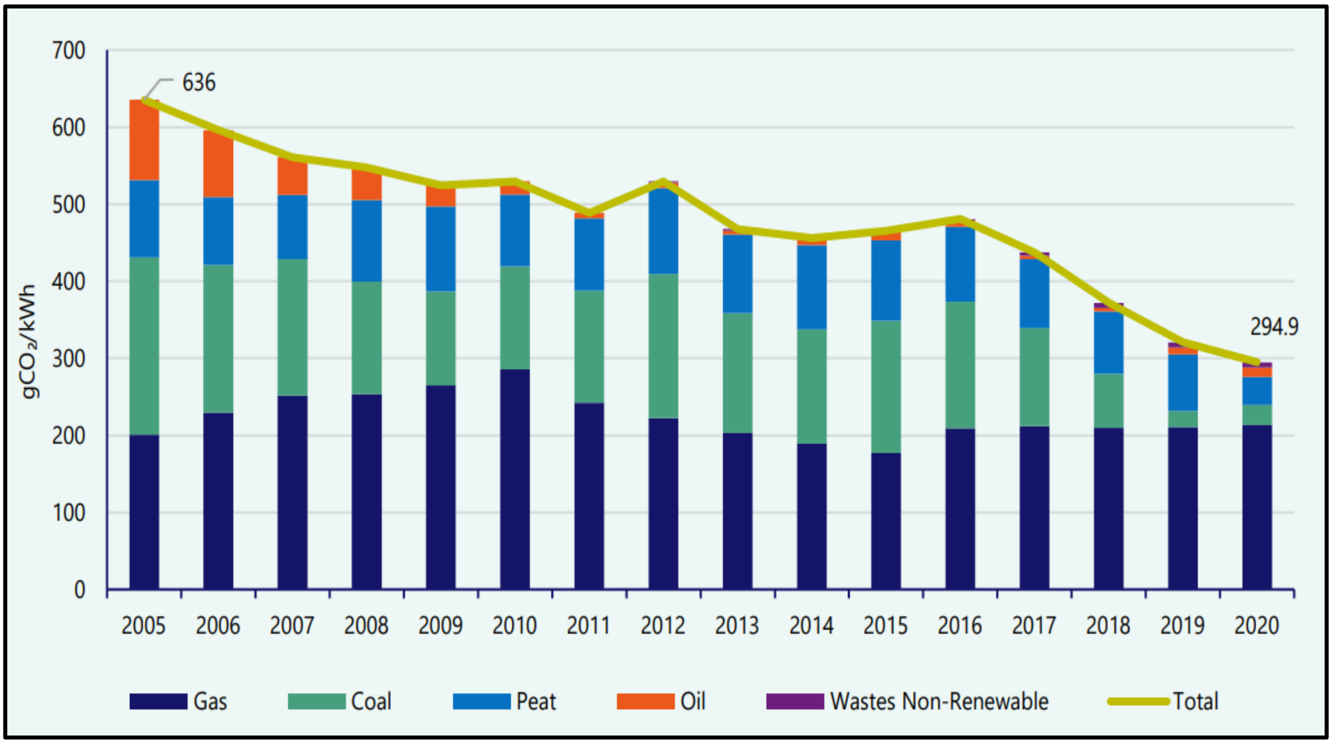
(SEAI, July Fuel Cost Comparison Survey, 2022)

Cost Saving @ €0.208 / kWh	Cost Saving @ €0.15 / kWh	Cost Saving @ €0.08 / kWh
€111,682	**€80,540**	**€42,955**

SEAI July Fuel Cost Comparison Survey Band IF: €0.208 excl. VAT

Carbon Emissions Savings **158 Tonnes of CO2 / Annum**

(SEAI, Energy CO2 emissions 2020 Short Note , 2020)



SEAI Energy CO2 Emissions Short Note: 294.9 g CO2 / kWh of electricity generated in Ireland.

https://www.seai.ie/publications/Energy-CO2-emissions-2020-Short-Note-FINAL.pdf

Savings Summary

	MPG-7-08635-03G	MVEE-F7-03	Savings
Yearly Consumption	2,122,078	1,585,141	**536,937 kWh**
Consumption per Filter	1,340 kWh	1003 kWh	**337 kWh**
Yearly Electrical Cost @ €0.208 / kWh	€441,392	€329,709	**€111,683**
Cost per Filter	€278.70	€208	**€70.50**
Yearly Emissions	626 tonnes CO2	467 tonnes CO2	**129 tonnes CO2**
Emissions per filter	395 kg CO2	295 kg CO2	**100 kg CO2**

SEAI July Fuel Cost Comparison Survey Band IF: €0.208 excl. VAT

SEAI Energy CO2 Emissions Short Note: 294.9 g CO2 / kWh of electricity generated in Ireland.

Bibliography

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