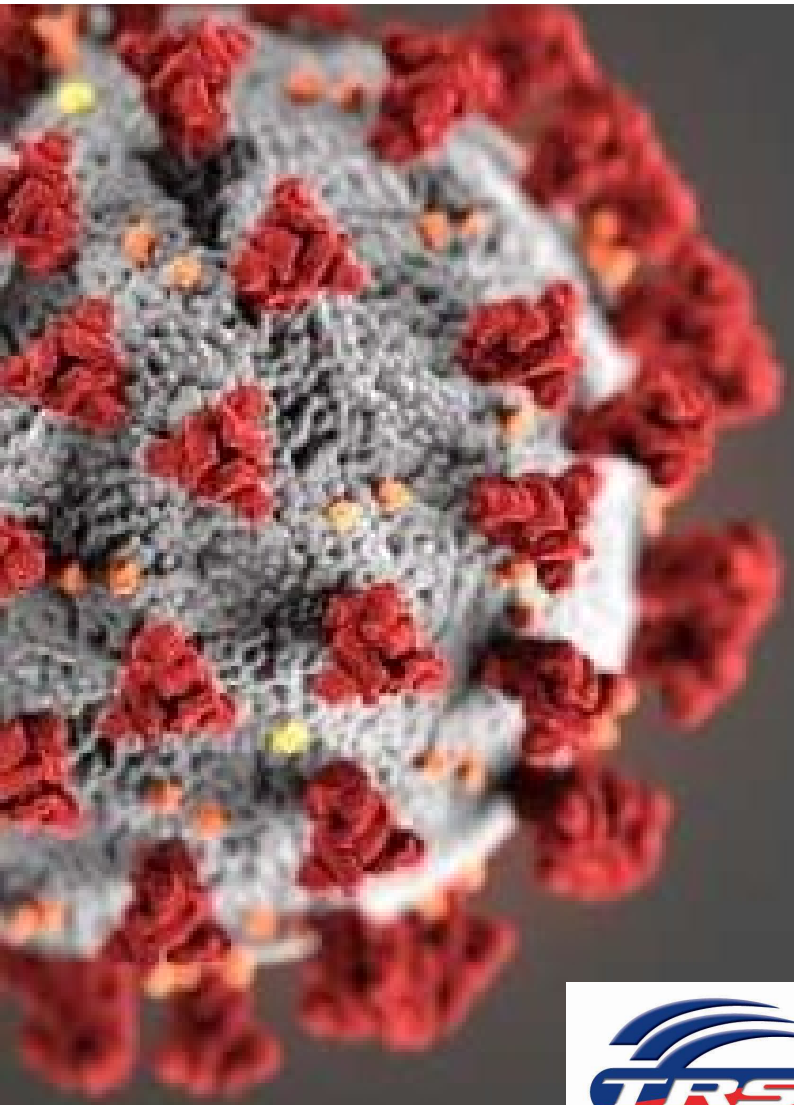

COVID-19 and the Future of Air Filtration

Joel Swann, Certified Air Filtration Specialist, Applications Engineer

(1) PDH: Virtual Presentation

September 2nd, noon

PRESENTED BY:

TRS

AAF Flanders

Joel Swann Introduction

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- HVAC Professional with 30+ years in design and manufacture of HVAC equipment
- Mechanical Engineering Bachelor of Science from University of Kentucky
- Certified Air Filtration Specialist by the National Air Filtration Association
- ASHRAE Associate
- Licensed Certified Residential Contractor by Florida Department of Business & Professional Regulation

Agenda

1. COVID-19 Background Summary
2. Filter Change Out PPE
3. Bypass Elimination
4. Best Mitigation Strategy
5. Quickest Mitigation Strategy
6. Air Cleaning Technologies: UVGI, Air Purifiers
7. Air Filtration Total Cost of Ownership

COVID-19 Background Summary

COVID-19 Disease Background Summary

What You Need to Know

What is the cause?

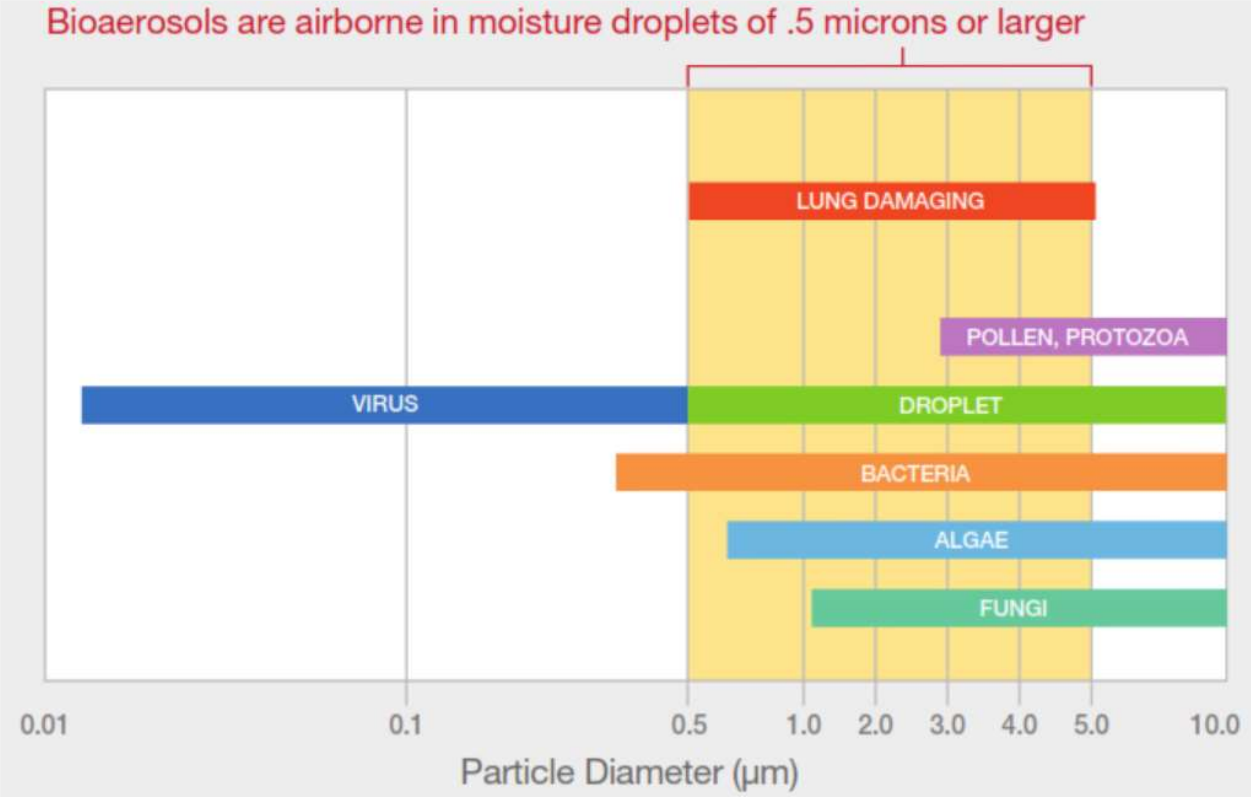
- A corona virus named SARS-CoV-2
- SARS-CoV-2 ≈ 0.12 μm in diameter (in other words 0.00000012 meters)

COVID-19 Research finds SARS-CoV-2 viable in airborne transmissions for up to 3 hours.

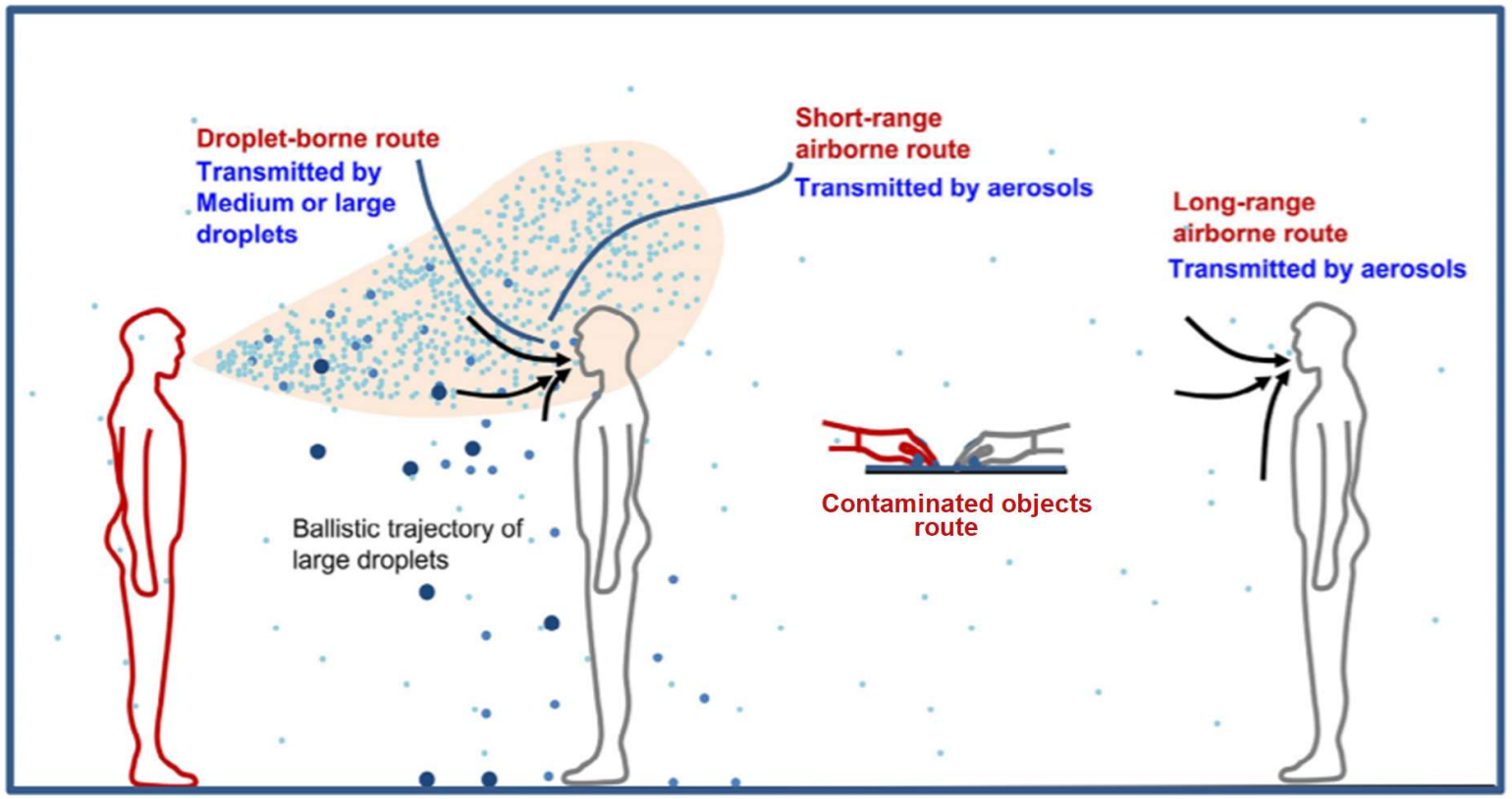
Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled.

COVID-19 Disease Background Summary

Can SARS-CoV-2 be transmitted through the air?



COVID-19 Disease Background Summary



- Large droplets (>100 µm) : Fast deposition due to the domination of gravitational force
- Medium droplets between 5 and 100 µm
- Small droplets or droplet nuclei, or aerosols (< 5 µm): Responsible for airborne transmission

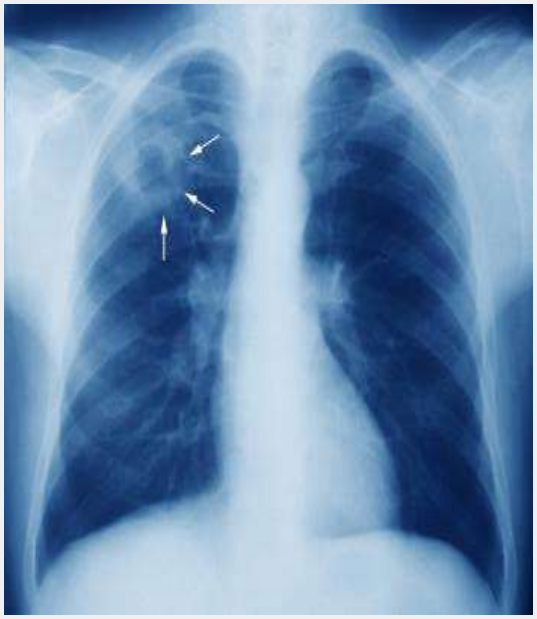
Ref. J.Wei, Y.Li: American Journal of Infection Control 44 (2016) S102-S108

COVID-19 Disease Background Summary

Airborne Disease Transmission modeling

Wells-Riley Equation: $C = S\,[1-\exp(-I \times q \times t / Q)]$

Developed by Wells and Riley to model the airborne transmission of Tuberculosis and the Measles



C = New Infections

S = Susceptible (reduce # of susceptibles, social distancing)

I = Infectors (reduce # of infectors, temperature screening)

q = quantity of viral dose (reduce dosage/breathing rate by wearing PPE, washing hands)

t = time of exposure (reduce time in high risk areas)

Q = Quantity of Clean Air (increase virus-free air)

- More ventilation in Air Changes/Hour (ACH)
- More high efficiency air filtration

COVID-19 Disease Background Summary

What are current positions regarding airborne transmission of SARS-CoV-2?

Mechanical Air Filters:

- *Air filtration is moving from "Occupant Comfort" to "Life Safety"*
- HVAC Building Readiness Recommendations:
  - Increased ventilation
  - Energy recovery ventilation systems plans
  - Increased filtration
  - Building exhaust air re-entrainment control
- Recommend that mechanical filter efficiency be at least MERV 13 and preferable MERV 14 or better to help mitigate the transmission of infectious aerosols.

Source: https://www.ashrae.org/technical-resources/building-readiness

Engineering Controls for SARS-CoV-2 include:

- Installing high-efficiency air filters.

Source: https://www.osha.gov/Publications/OSHA3990.pdf

Consider improving the engineering controls using the building ventilation system:

- Improve central air filtration to the MERV-13 or the highest compatible with the filter rack, and seal edges of the filter to limit bypass.

Source: https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html

Transmission of SARS-CoV-2

- Airborne transmission of the virus can occur in health care settings where specific medical procedures, called aerosol generating procedures, generate very small droplets called aerosols.

Source: https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions

Filter Change Out PPE

Filter Change Out PPE

Maintaining Preventative Maintenance Schedules

- Refer to CDC Guidance on PPE use. The risks associated with handling filters possibly contaminated with SAR-CoV-2 under field-use conditions have not yet been evaluated. Updates will follow.

Properly Fitted Respirator
N95 Mask or higher

Eye Protection
Safety Glasses, Goggles or Face Shield

+

Disposable Gloves

+

Protection suits
(full hooded coveralls, gowns)

Disposable Foot Covers

=

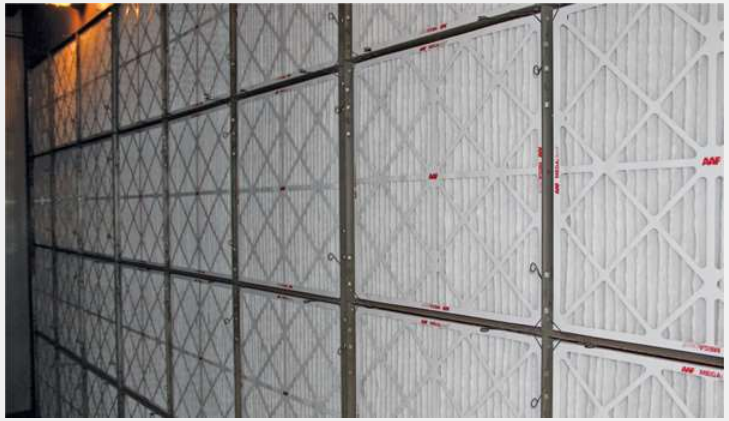
Filter Change Out Procedural Additions

Maintaining Preventative Maintenance Schedules

1. Turn off the AHU.

2. Before touching the dirty filters, spray the face of the filter with disinfectant, followed by a fixate spray (i.e. hairspray)

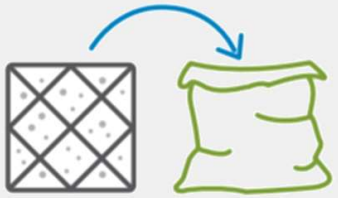
3. Carefully remove the filters to minimize vibration and particle shedding.



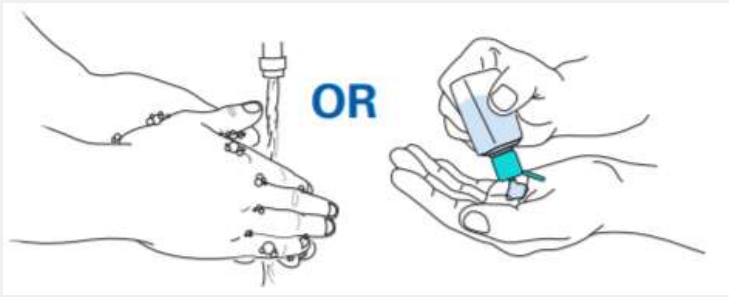
Filter Change Out Procedural Additions

Maintaining Preventative Maintenance Schedules

4. Consider bagging filters, particularly if filters are suspected to be contaminated with SARS-CoV-2.



5. Dispose of bagged filters per normal procedures.



6. When maintenance complete, remove protective gear, and wash with soap & water or hand sanitizer.

Bypass Elimination

Quickest Filtration Mitigation Strategy

Seal Filtration Racks from By-Pass

Air filter bypass is a common problem, but now it is more critical than ever!

Bypass occurs when filter media is not properly sealed in the filter frame.

In order to have the filters perform as rated, air must be forced to pass through the filters.

- A 1 mm gap in the installation of a MERV 15 filter can reduce its efficiency to MERV 14*.
- A 10 mm gap (less than ¼") can drop a filter's MERV rating by 2 levels*.
- Because higher efficiency filters typically have a higher pressure drop, bypass in those filters are more adversely effected.

- Source: ASHRAE Transactions, 2005: Filter Bypass: Implications for Filter Efficiency

Quickest Filtration Mitigation Strategy

Seal Filtration Racks from By-Pass

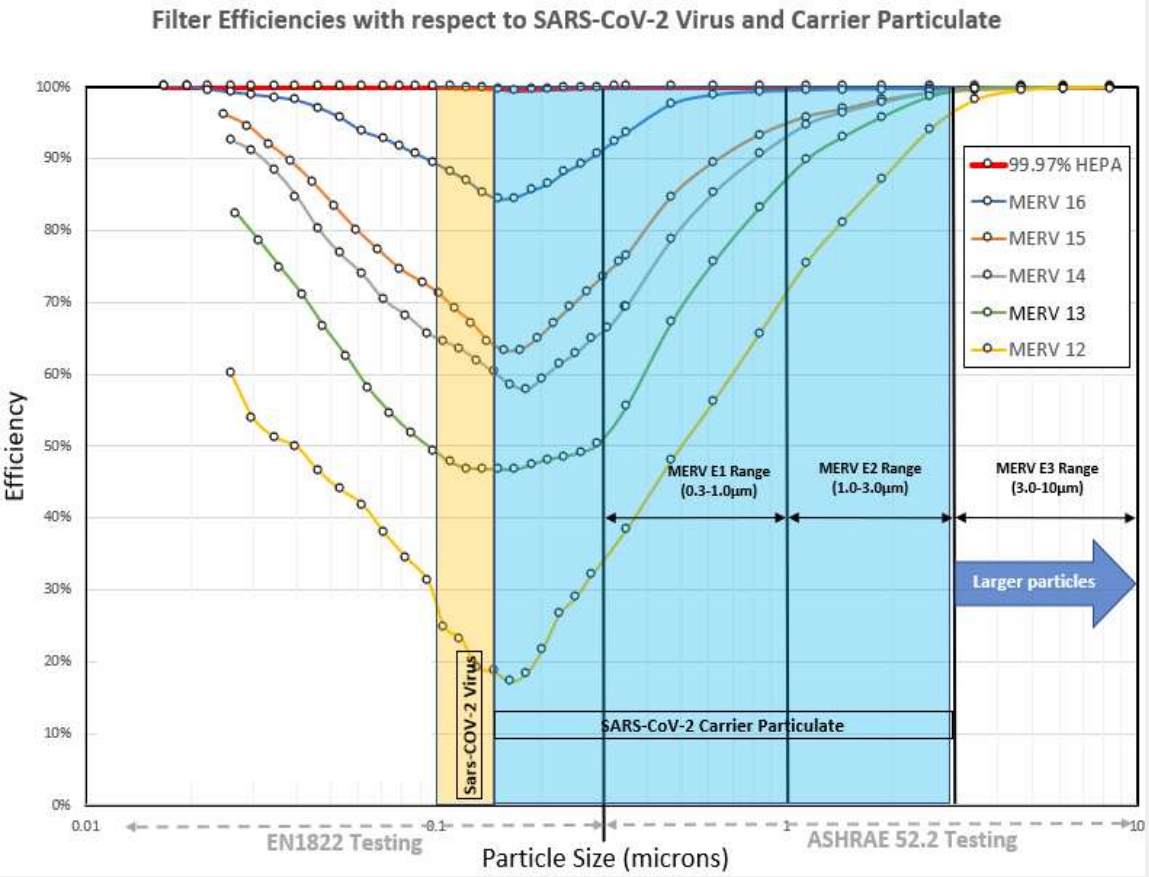
Filter Frame Maintenance Tips

- Caulk or gasket cracks between filter frames.
- Gasket filter housing channel or frames.
- Gasket vertical sides between filters, frames, tracks and doors.
- Install all filter fasteners securely.
- Install all block offs and tighten in place.

Best Mitigation Strategy

Upgrade to HEPA Filtration

HEPA Filtration: 99.97% Efficiency at 0.3 µm

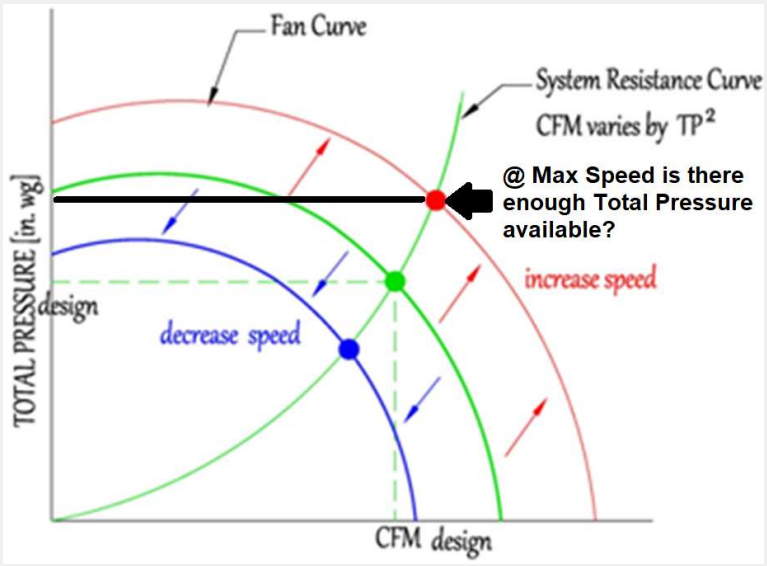


- Fragile small virus tend to move in the airflow by “piggybacking” on or within a slightly larger bioaerosol particle
- However, some early studies have shown the SARS-CoV-2 virus to be viable even when traveling alone.
- To address this viable situation, its individual size is approximately 0.12µm, would require HEPA filtering efficiency.

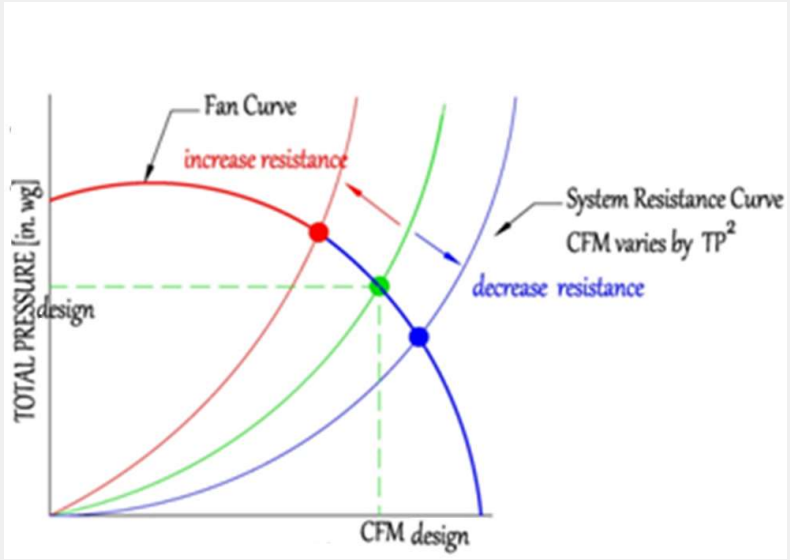
Best Filtration Mitigation Strategy - HEPA

Upgrade to HEPA Filtration Systems – 99.97% Efficiency

- Consider Pressure Drop: Do you have enough fan static pressure?



Variable Air Volume System Fan Curve

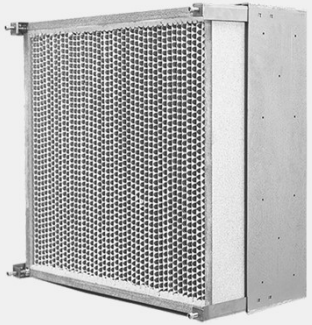


Fixed Speed System Fan Curve

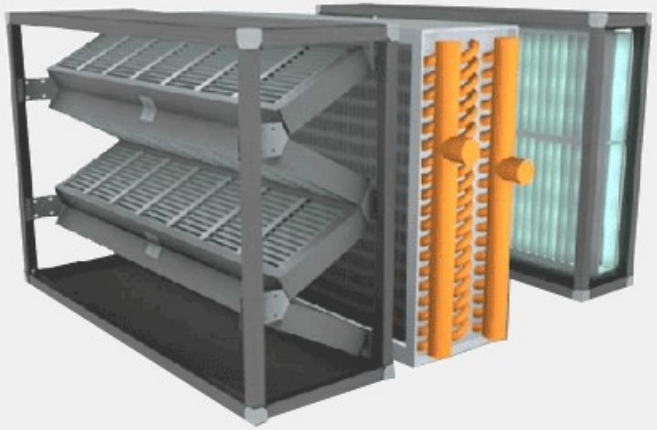
Best Filtration Mitigation Strategy

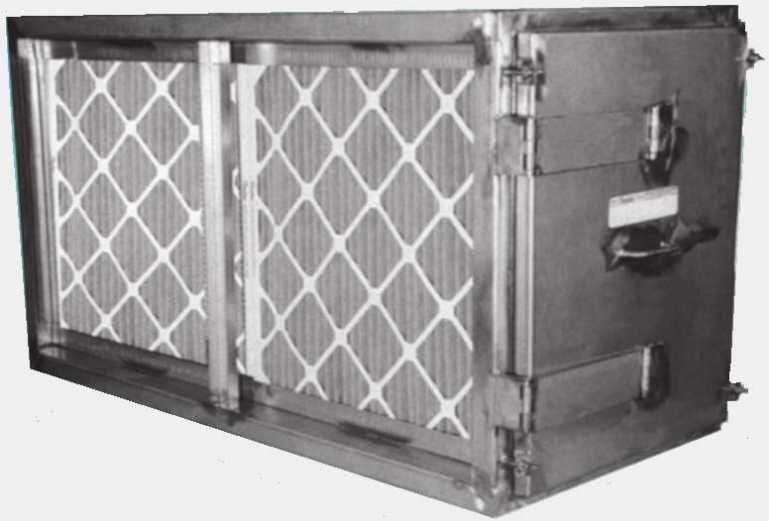
Upgrade to HEPA Filtration Systems

- Add racks: Is there serviceable clearance upstream of frame?



- Consider Door Clearance: Will the filter fit? Is it accessible by technician?





- Consider HEPA Filter Housings: Surelock B, Surelock C3, or Surelock C4

Best Filtration Mitigation Strategy

Pick the right HEPA Filter for the Job

MEGAcel I eFRM (H13)

- 0.7” w.g.
- 99.97% at 0.3 µm
- Separator Style
- $$$

MEGAcel I eFRM (H14)

- 1.0” w.g.
- 99.99% at 0.3 µm
- Separator Style
- $$$

AstroPak

- 1.6” w.g.
- 99.97% at 0.3 µm
- Separator Style
- $

decreasing **INITIAL RESISTANCE at 500 FPM** **increasing**

AstroCel III or SuperFlow 24

- 0.8” w.g.
- 99.99% at 0.3 µm
- V-bank Minipleat Style
- $$$

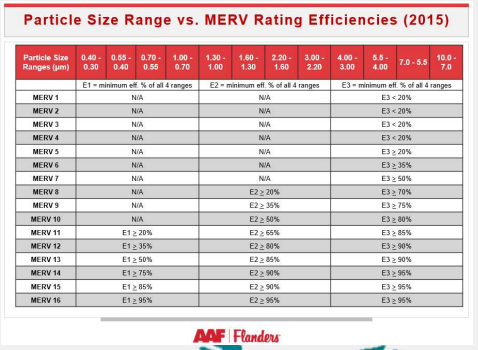
AstroCel I HCX or Alpha 2000

- 1.4” w.g.
- 99.97% at 0.3 µm
- Separator Style
- $$

Quickest Mitigation Strategy

Quickest Filtration Mitigation Strategy

Upgrade to ASHRAE MERV 16 Filters in Existing Racks, if possible



<u>MERV 16 Filters are the highest efficiency per ASHRAE 52.2 rating!</u>

MERV 16 filters remove more of the smaller aerosolized respiratory droplets (sized 0.5 µm to 5.0 µm), thereby capturing them and the SARS-CoV-2 virus that may be riding along.

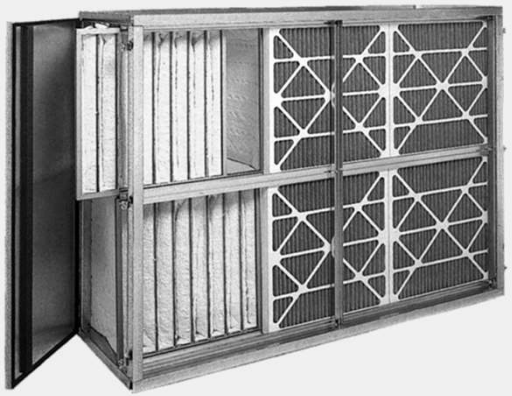
.

Particle Size Range	Minimum Efficiency %								
	MERV 8	MERV 9	MERV 10	MERV 11	MERV 12	MERV 13	MERV 14	MERV 15	MERV 16
0.3 - 1.0 µm	N/A	N/A	N/A	E_1≥20%	E_1≥35%	E_1≥50%	E_1≥75%	E_1≥85%	E_1≥95%
1.0 - 3.0 µm	E_2≥20%	E_2≥35%	E_2≥50%	E_2≥65%	E_2≥80%	E_2≥85%	E_2≥90%	E_2≥90%	E_2≥95%
3.0 - 10.0 µm	E_3≥70%	E_3≥75%	E_3≥80%	E_3≥85%	E_3≥90%	E_3≥90%	E_3≥95%	E_3≥95%	E_3≥95%

MERV 16 Upgrade Considerations

Before Ordering New Filters, Verify Existing System Can Accommodate MERV 16 Requirements

- Consider Pressure Drop: Do you have enough fan static pressure?
- Consider MERV 16 Filters are 6-12” Deep with 1” Header: Will it fit in the rack and is there clearance in the AHU upstream and downstream of the rack.
- Consider Door Clearance: Will the filter fit? Is it accessible by technician?
- Add racks: Make sure there is serviceable clearance upstream of frame and through access door.
- Consider ASHRAE Filter Housings: SureSeal



Best Filtration Mitigation Strategy

Pick the right ASHRAE Filter for the Job

Best

BioCel VXL

- MERV 16
- 12” Deep, SH
- 0.60” w.g.
- $$$
- OPT: Antimicrobial

BioCel M-Pak

- MERV 16
- 6” Deep, SH
- 0.78” w.g.
- $$

PrecisionCell M16

- MERV 16
- 12” Deep Box Style, SH, Double Turn Flange
- 0.76” w.g.
- $$

BioCel I

- MERV 16
- 6” (250 FPM Max), 12” Deep, SH, DH
- 1.0” w.g.
- $

AAF | Flanders

Quickest Filtration Mitigation Strategy

Upgrade to Higher ASHRAE MERV Filters in Existing Racks

ANY Upgrade in Filters ≤ MERV 8 Mitigates Risk of Bioaerosols in Air Stream

ASHRAE 52.2 MERV 13 are efficient at capturing aerosolized respiratory droplets sized 0.5 µm to 5.0 µm, **Therefore, the minimum recommended final filter rating is MERV 13,** MERV 14 preferred, or as best achievable without diminishing air flow*.

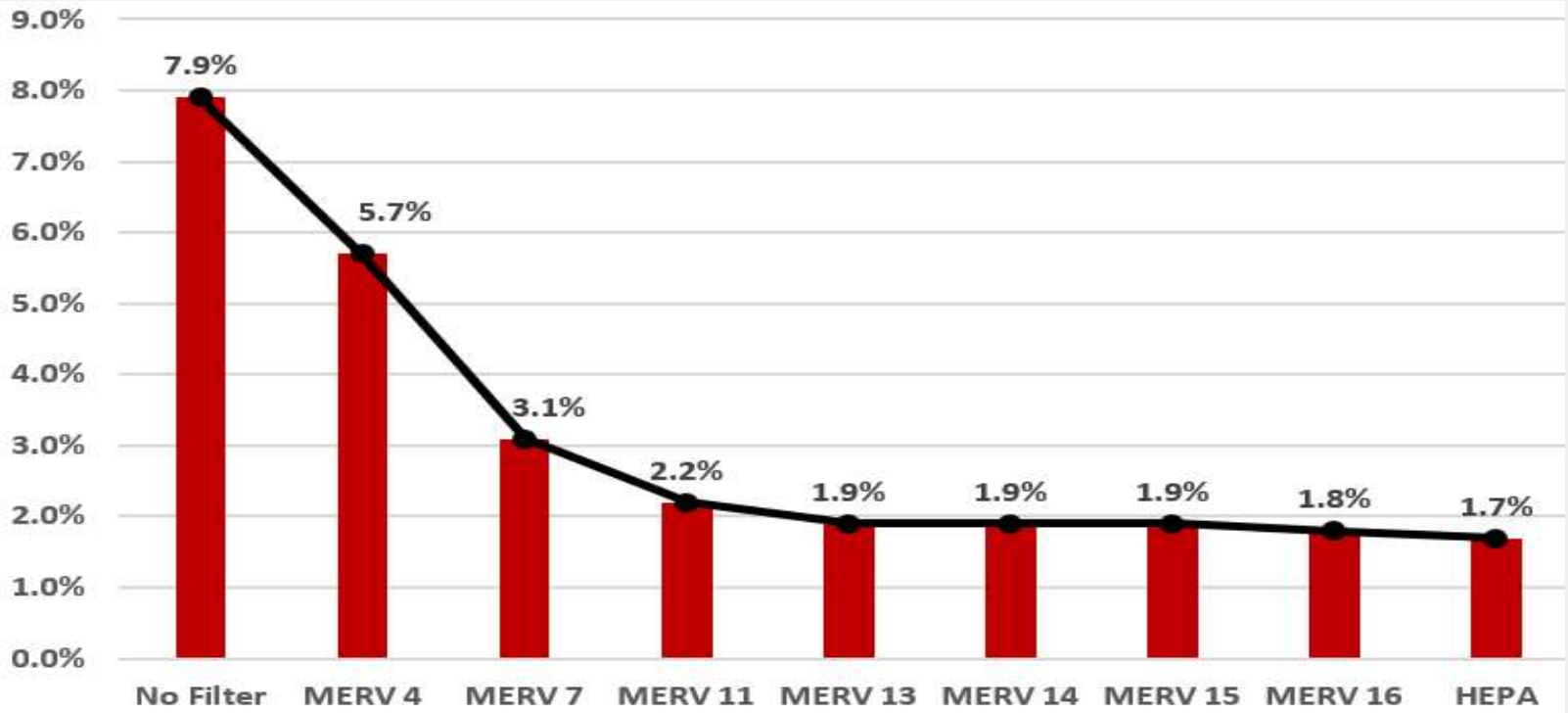
ASHRAE * ASHRAE Guidance for Filtration Disinfection during the COVID-19 Pandemic, March 27, 2020

If constrained by available fan static pressure, filter rack size, or availability, consider any upgrade in MERV rated filters mitigates the percentage of bioaerosol particles in the air.

Particle Size Range	Minimum Efficiency %								
	MERV 8	MERV 9	MERV 10	MERV 11	MERV 12	MERV 13	MERV 14	MERV 15	MERV 16
0.3 - 1.0 µm	N/A	N/A	N/A	E_1≥20%	E_1≥35%	E_1≥50%	E_1≥75%	E_1≥85%	E_1≥95%
1.0 - 3.0 µm	E_2≥20%	E_2≥35%	E_2≥50%	E_2≥65%	E_2≥80%	E_2≥85%	E_2≥90%	E_2≥90%	E_2≥95%
3.0 - 10.0 µm	E_3≥70%	E_3≥75%	E_3≥80%	E_3≥85%	E_3≥90%	E_3≥90%	E_3≥95%	E_3≥95%	E_3≥95%

Infection Risk v. Filter Efficiency Rating

Reasons why MERV 13 is minimum recommendation



Ref. NAFA Research on HVAC filtration and the Wells-Riley approach to assessing risks of infectious airborne diseases prepared by Dr. Brent Stephen: Projected risk of infection by influenza virus during a 2-hour stay in a hypothetical hospital waiting room environment with 50 adult occupants and ASHRAE 170 minimum ventilation rates.

http://built-envi.com/publications/nafa_iit_wellsriley%20-%20FINAL.pdf

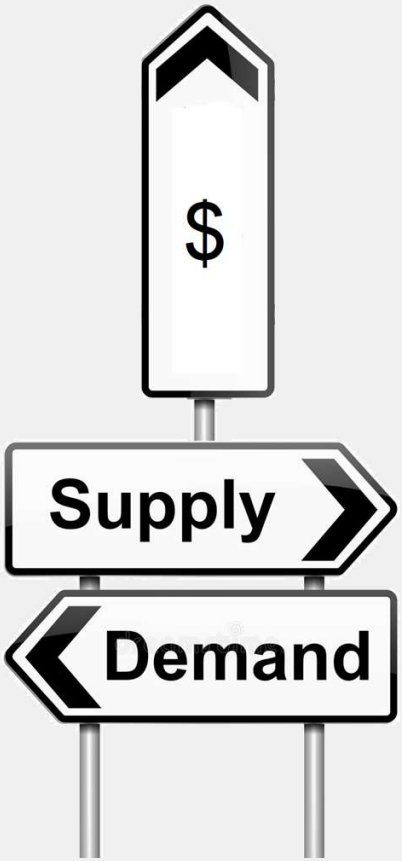
MERV 13 Filter Shortages

Recommendations Cause Demand >> Supply

- Commercial markets were generally MERV 8 Pre-Filters and MERV 11-15 Final Filters, so supply chain production capability mirrored that demand.
- Market is now showing a 300% MERV 13 increase in demand YOY, 2019-2020.
- Remember that *minimum recommend final filter rating is MERV 13,* consider using higher efficiency MERV 14, 15, 16 filters.
- Remember that *'or as best achievable'* can include lower efficiency MERV 12, 11, 10, 9 filters. Any increase in MERV rating over existing mitigates risk.
- Will likely adjust over time, consider alternatives as interim, short-term solution vs. final Post-COVID-19, long-term solution.

Meltblown Synthetic Shortages

Competition with PPE Masks & Gowns Cause Demand >> Supply



- Demand + Government 1st Out Contracts has created a Meltblown Synthetic Shortage
- Has created an industry-wide lofted filter media shortage
- Lofted filter media used in higher efficiency products such as MERV 11 – MERV 15 Box Filters and Bag Filters
- Laws of Supply & Demand have created a price driven response across the market

Best Filtration Mitigation Strategy

Pick the right ASHRAE Filter for the Job

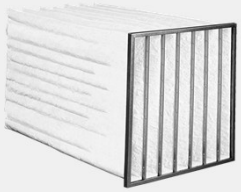
Better

VariCel VXL
- MERV 11, 13, 14, 15
- 12” Deep
- 0.28 – 0.38” w.g.
- $$$

VariCel 2+ HC
- MERV 11, 14, 15
- 4” Deep Box Style
- 0.38 – 0.56” w.g.
- $$

DriPak GX & NX
- MERV 13, 15
- Bag Style, SH
- 0.25 – 0.52” w.g.
- $$

VariCel II
- MERV 11, 14, 15
- 4” Deep Box Style
- 0.47 – 0.63” w.g.
- $$



DriPak & DriPak 2000
- MERV 12,13, 14, 15
- Bag Style, SH
- 0.25 – 0.52” w.g.
- $

VariCel RF
- MERV 11, 12, 14, 15
- 12” Deep, SH, DH, No Header
- 0.25 – 0.69” w.g.
- $$

Best Filtration Mitigation Strategy

Pick the right ASHRAE Filter for the Job

Good

PrecisionCell III
- MERV 11, 13, 14
- 2”, 4”, 6” Deep Box Style
- 0.20 – 0.26” w.g.
- $$

VariCel M-Pak
- MERV 11, 13, 14
- 6” Deep
- 0.24 – 0.40” w.g.
- $$

SuperFlow Q
- MERV 11, 14
- 12” Deep
- 0.26 – 0.44” w.g.
- $$

VariCel I
- MERV 11, 13, 14
- 6” (250 FPM Max), 12” Deep, SH, DH
- 0.40 – 0.59” w.g.
- $

PrecisionCell GT
- MERV 11, 14
- 12” Deep, SH, DH
- 0.45 – 0.65” w.g.
- $

Best Filtration Mitigation Strategy

Pick the right Single-stage or Pre-Filter for the Job

Good

MEGApleat M9

- MERV 9
- 1”, 2”, 4” Deep
- 0.17 – 0.38” w.g.
- $$

Better

PREpleat M11 HC

- MERV 11
- 1”, 2”, 4” Deep
- 0.23 – 0.38” w.g.
- $$

Best

PrecisionCell III

- MERV 11, 13, 14
- 2”, 4”, 6” Deep Box Style
- 0.20 – 0.26” w.g.
- $$$

PREpleat M13

- MERV 13
- 1” (375 FPM Max), 2”, 4” Deep
- 0..20 – 0.30” w.g.
- $$

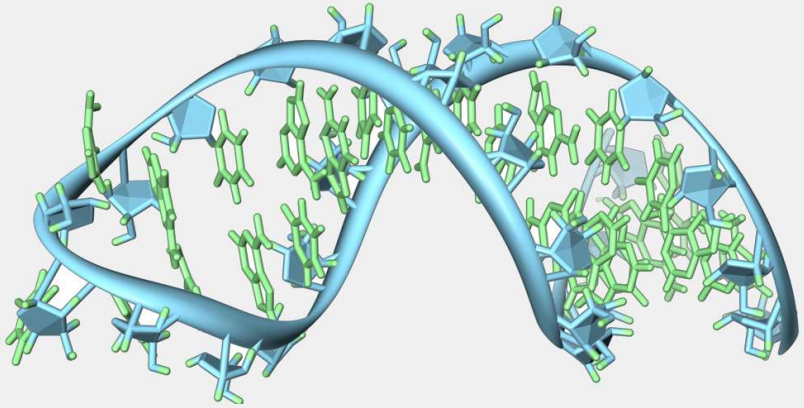
Other Air Cleaning Solutions: UVGI, Air Purifiers

Other Filtration Mitigation Strategies

Air Handlers with Ultra Violet Germicidal Irradiation (UVGI) in Filters

How UV Lights Works in Air Handler Units

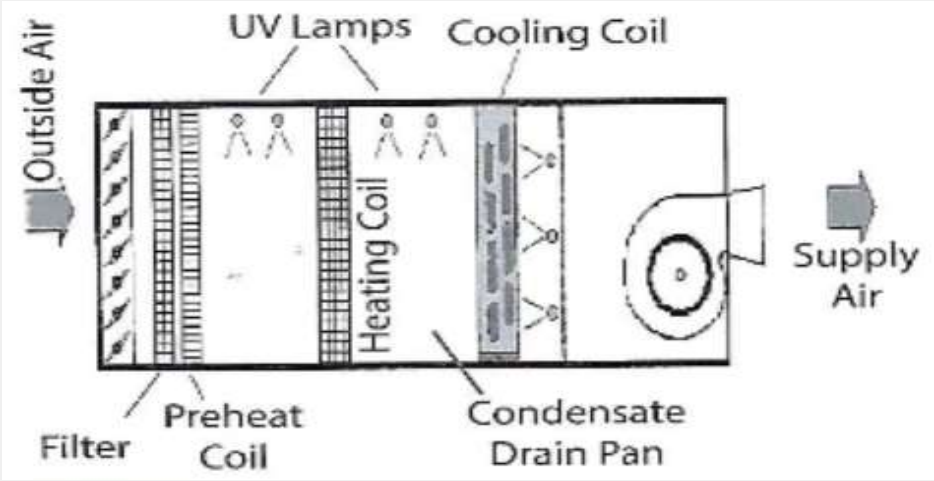
The RNA of the virus absorbs the radiant energy which results in breaks and lesions in the chain

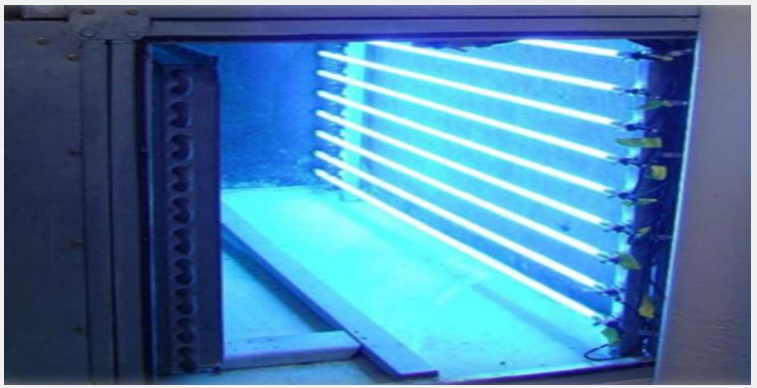


Other Filtration Mitigation Strategies

Air Handlers with UV Light in Filters

- UV Lamps are normally placed on the downstream side of the coil and over the drain pan.
- UV Lamps create UVC wavelengths, the most effective on organic matter, including human eyes and skin – use caution.
- Open cell sealing foam, polypropylene synthetic fibers, and other plastics can become brittle or break down completely with prolonged exposure to UVC.
- If UV lights are part of the filtration system, use only non-synthetic filter components (i.e. fiberglass filter media).

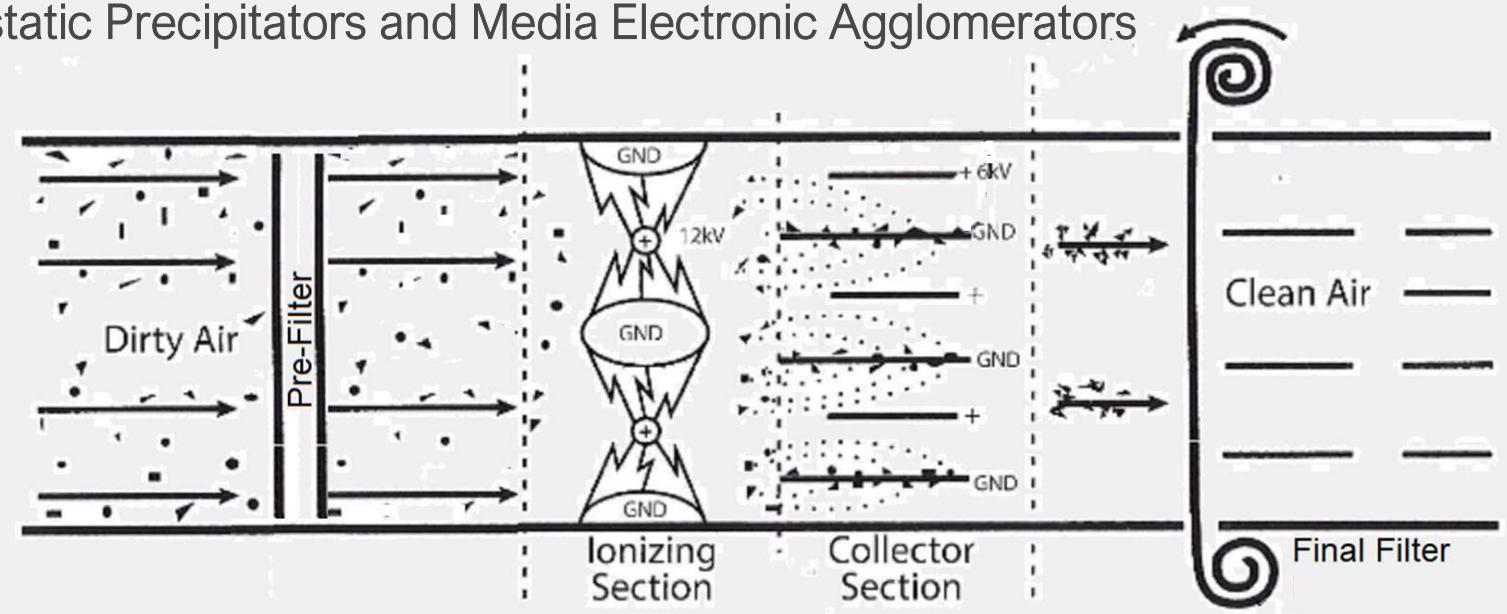




Other Filtration Mitigation Strategies

Air Purifiers - built for use with Mechanical Filtration

Air Purifiers use the principle of electrostatic precipitation and are also know as Electrostatic Precipitators and Media Electronic Agglomerators



- Efficiency is highest when the Collector Plates are clean.
- Balances charging strength for efficiency with risk of ozone (O_3) creation

Other Filtration Mitigation Strategies

Filter Recommendations for use with Air Purifiers

- Pre-Filter with a minimum MERV 8 filter to minimize risk of arcing in the Ionizing Section and premature loading in the Collector Section
- Final Filter with a minimum MERV 13 filter to capture agglomerated particles and meet minimum COVID-19 response criteria

Air Filtration
Total Cost of Ownership (TCO)

Better Filter Efficiencies at Lower Costs

17 Tiz the Law

3-5

Own: Sackatoga Stable
Burgundy, Grey Diamonds, Grey Sleeves

FRANCO M (—) 2020: (651 100 .15)

B. c. 3 (Mar) SARAUG18 $110,000
Sire: Constitution (Tapit) $40,000
Dam: Tizfiz (Tiznow)
Br: Twin Creeks Farm (NY)
Tr: Tagg Barclay(—) 2020:(48 9 .19)

L 126

	Life	7	6	0	1	$2,015,300	109
	2020	4	4	0	0	$1,668,300	109
	2019	3	2	0	1	$347,000	90
	CD	1	0	0	1	$29,100	80

	D.Fst	6	6	0	0	$1,986,200	109
	Wet(350)	1	0	0	1	$29,100	80
	Synth	0	0	0	0	$0	–
	Turf(325)	0	0	0	0	$0	–
	Dst(304*)	1	1	0	0	$535,000	109

TimeformUS Pace: Early **96** Late **98**

8Aug20-11Sar	fst	1¼	:48.36	1:11.95	1:36.42	2:00.95	Travers-G1	**109**	5/7	31	3½	1½	14½	15½	Franco M	L126	*.50	101–08	Tiz the Law1265¾ Caracaro1262 **Max Player**1262	Perched 3w, impressive
20Jun20-10Bel	fst	1⅛	:46.16	1:09.94	1:34.46	1:46.53	Belmont-G1	**100**	8/10	32	32	31½	14	13¾	Franco M	L126	*.80	101 –	*Tiz the Law*1263¾ Dr Post1261½ **Max Player**1262½	3w,ask 3/16,kick away
28Mar20-14GP	fst	1⅛	:47.95	1:11.94	1:36.79	1:50.00	FlaDerby-G1	**96**	4/9	41¾	3½	3½	11	14¼	Franco M	L122	*1.40	84–12	*Tiz the Law*1224¼ Shivaree122¾ Ete Indien122nk	Stalk3wd,drive1/8-1/16
1Feb20-11GP	fst	1 1/16	:23.31	:46.60	1:10.96	1:42.04	HolyBull-G3	**100**	3/7	31	42	2hd	11	13	Franco M	L124	*1.30	99–13	*Tiz the Law*1243 *Ete Indien*12011½ Toledo11841¼	Wrangle bk,stdy,lug in
30Nov19-11CD	sly^{S}	1 1/16	:24.39	:49.92	1:14.83	1:45.94	KyJC-G2	**80**	3/8	32	42½	41	3½	3¾	Franco M	L122	*.60	75–21	SilverProspector122¾ **FinnickthFirc**122hd *TizthLw*1221¼	Pocketed,asked 3/16
5Oct19-10Bel	fst	1	:22.57	:46.15	1:10.82	1:35.41	Champagn-G1	**89**	6/6	53	52½	31½	11	14	Franco M	L122	1.40	86–16	Tiz the Law1224 Green LightGo122nk BigCityBob122½	Stmble st,2w,trffic1/4
8Aug19-5Sar	fst	6½f	:22.30	:46.16	1:11.29	1:18.02	S Md Sp Wt 78k	**90**	3/8	2	42	42	12	14¼	Alvarado J	L119	3.55	83–18	*TizthеLaw*1194¼ DremBigger11914 BrillintBrooks1198	2w,lug in1/8,unask1/16

WORKS: 29Aug20 Sar 5f fst :59¹ B *1/3* ●23Aug20 Sar 5f fst :59² B *1/39* 1Aug20 Sar 5f fst :59⁴ B *2/24* 25Jly20 Sar 5f fst 1:00² B *2/16* ●18Jly20 Sar 5f fst :59³ B *1/20* 8Jly20 Bel 5f fst 1:01 B *2/8*

Air Filters Maintenance Plans

Pick Your Plan!

On the Calendar

On the Pressure Gauge

On the Money

Change Filters "On the Money"

a.k.a. Condition Based Maintenance Plan (CBMP)

Def. – when a filter's total cost of ownership is at a minimum based on all the costs associated with a filter change out:

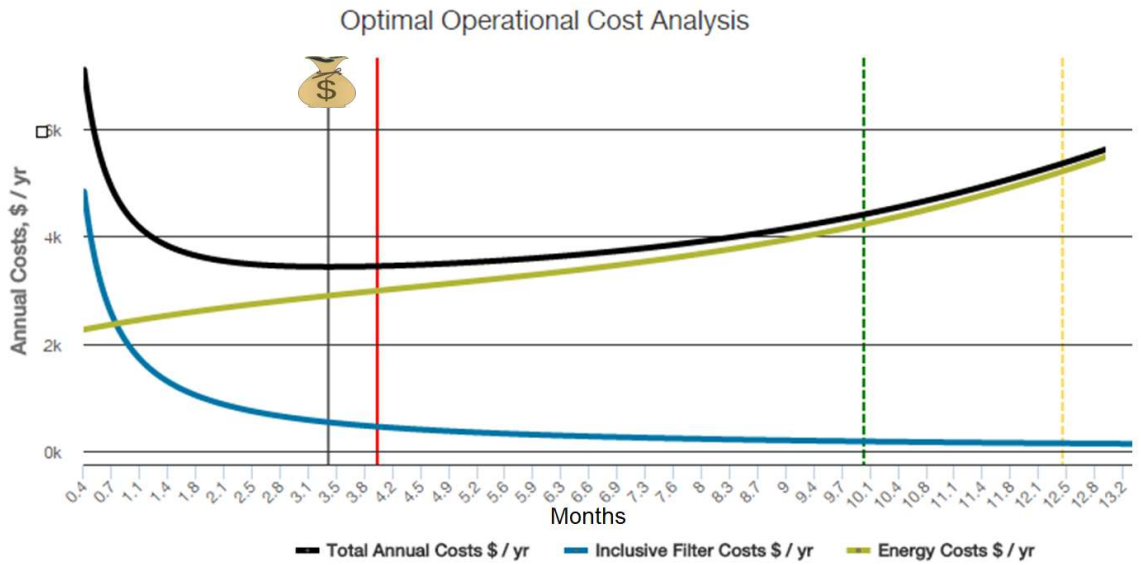
- Filter
- Ordering Labor
- Change-out Labor
- Freight
- Disposal
- Energy

Advantages:

- Saves money, lowest cost
- Analysis based on exact system data
- Routine
- Easy to Budget

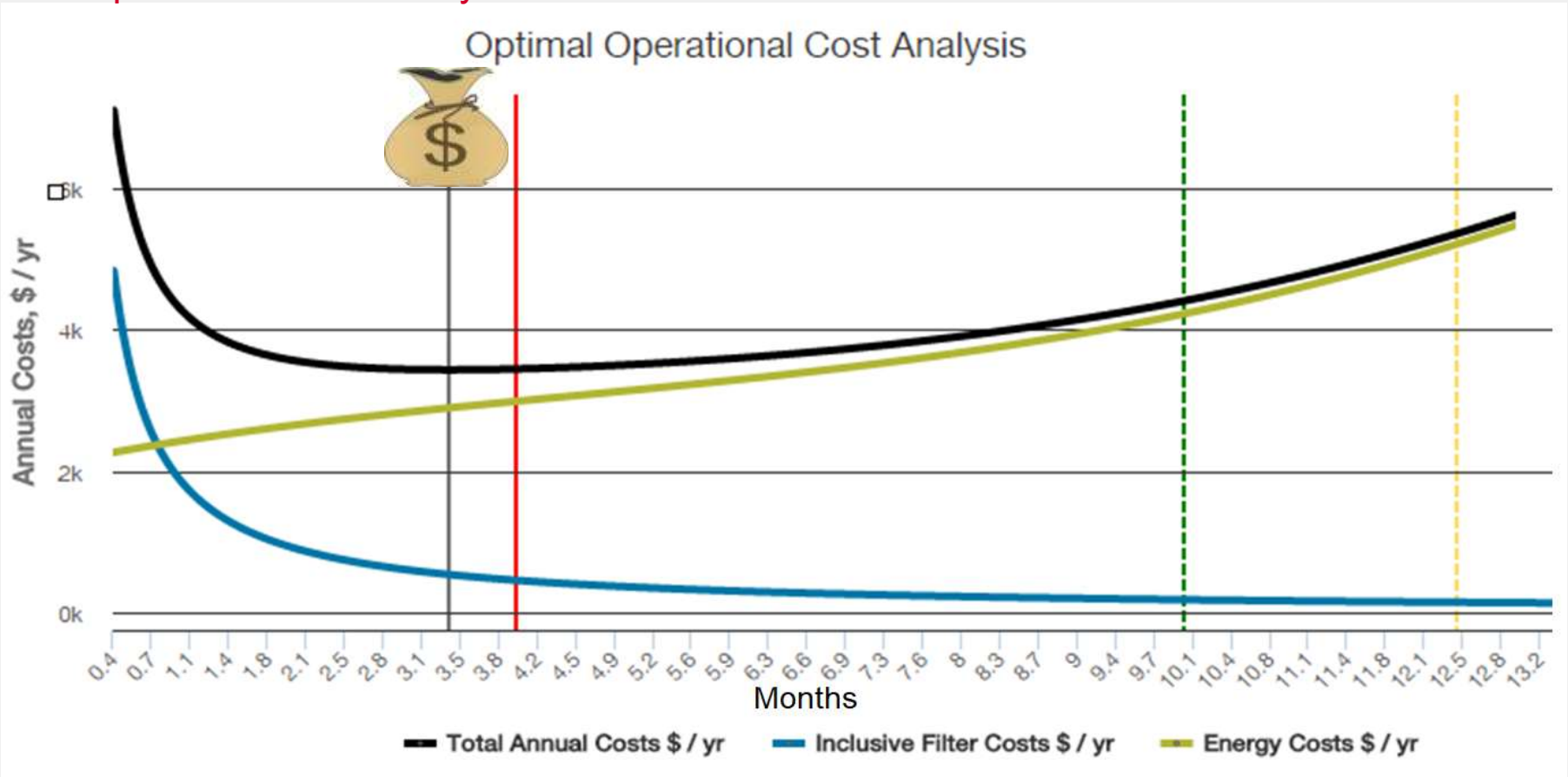
Disadvantages:

- Requires effort to obtain data

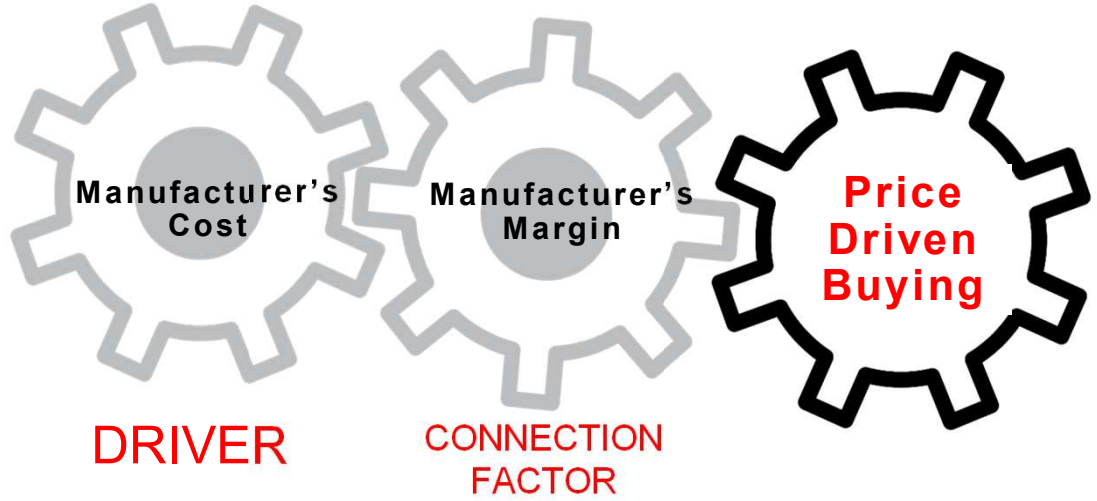


Change Filters “On The Money”

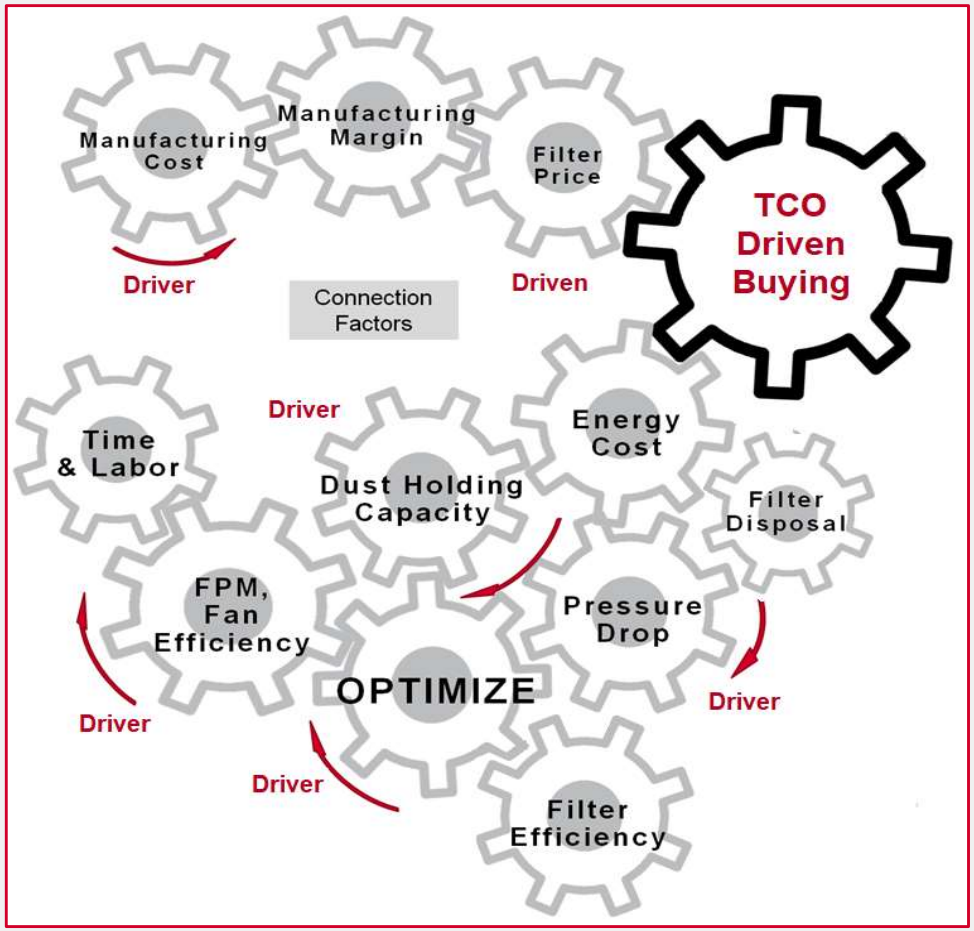
Optimal Operational Cost Analysis



Price-Driven Buying



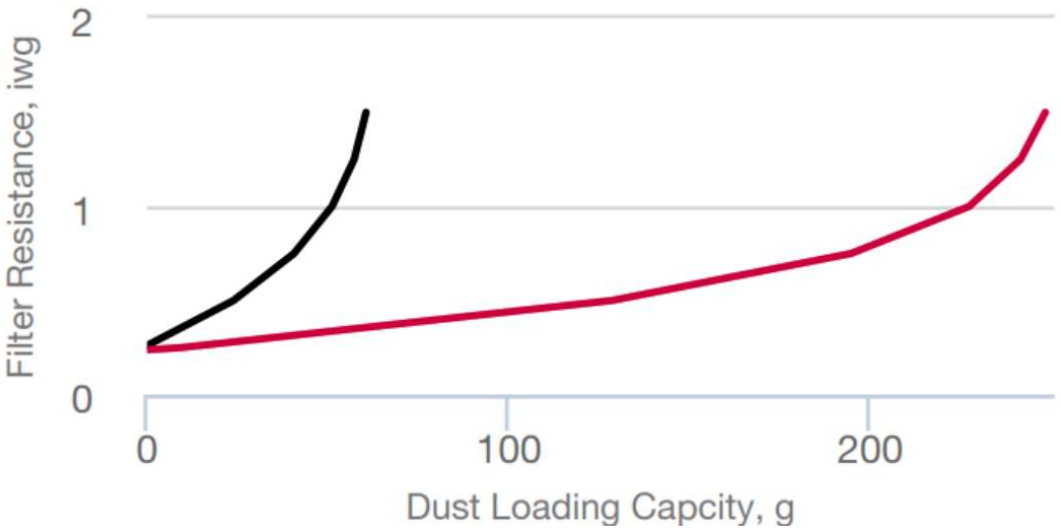
Total Cost of Ownership (TCO) Buying



$$W = \frac{q_V \cdot \overline{\Delta p} \cdot t}{\eta \cdot 1000}$$

W	=	annual energy consumption (kWh)
q_V	=	airflow rate (m^3/s)
$\overline{\Delta p}$	=	average pressure drop (Pa)
t	=	annual operating time (hours)
η	=	fan efficiency (%)

Why Use a Filter Optimization Program?



Current System

Proposed

Savings of Upgrading Air Filters

Is it possible to reduce TCO in a post COVID-19 world?

Moving from a Two-Stage MERV 11 System to a Two-Stage MERV 15

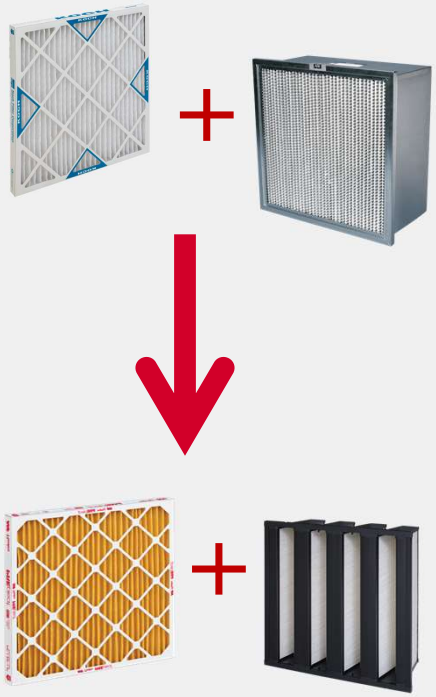
Assumptions:

- 10,000 CFM AHU
- Electricity Cost = $0.08 kWh
- Average Filter Costs
- Maintenance Costs = $40/hour
- Freight Costs = $90/AHU
- Disposal Costs = $50/AHU
- Dust Loading = 27 grams/month

Savings of Upgrading Air Filters

Annualized Results

Moving from a Two-Stage MERV 11 System to a Two-Stage MERV 15



Results

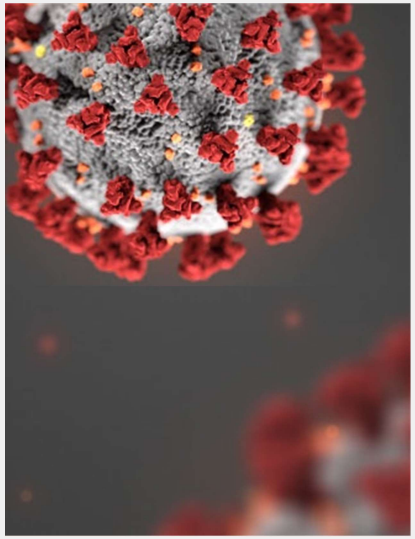
Koch Filter Corporation
S1: Multi-Pleat™ XL8 SC-M8-2
S2: Multi-Cell™-M11-12

Total Cost of Ownership $ Spent Per Year	Current System
Filter Cost	$413.3
Energy Cost	$1,188
Labor Cost	$243
Disposal Cost	$96
Other Identified Costs	$213
Total Cost of Ownership	**$2,154**
Environmental Impact (CO_2 Emmissions)	133.6
Labor Hours Consumed	6.1

16.3% Reduction

Executive Summary

COVID-19 and the Future of Air Filtration



- Upgrading to HEPA filtration is the recommended best COVID-19 mitigation response.
- If HEPA filters are not compatible with existing system, upgrading to ASHRAE MERV 16 filtration is the recommend best ‘quick’ mitigation response.
- If ASHRAE MERV 16 filters are not compatible with existing filter racks, the minimum recommended upgrade is ASHRAE MERV 13, MERV 14 preferred, or the highest level achievable.
- COVID-19 Filter upgrade cost increases can be minimized or eliminated with a Total Cost of Ownership (TCO) perspective.
- TRS offers the full range of AAF Flanders products to provide the best ‘fit’ for each unique system.
- TRS and AAF Flanders engineering leadership in COVID-19 mitigation response is available to develop unique mitigation plans.