FIGHTING COVID-19 WHILE IMPROVING SUSTAINABILITY

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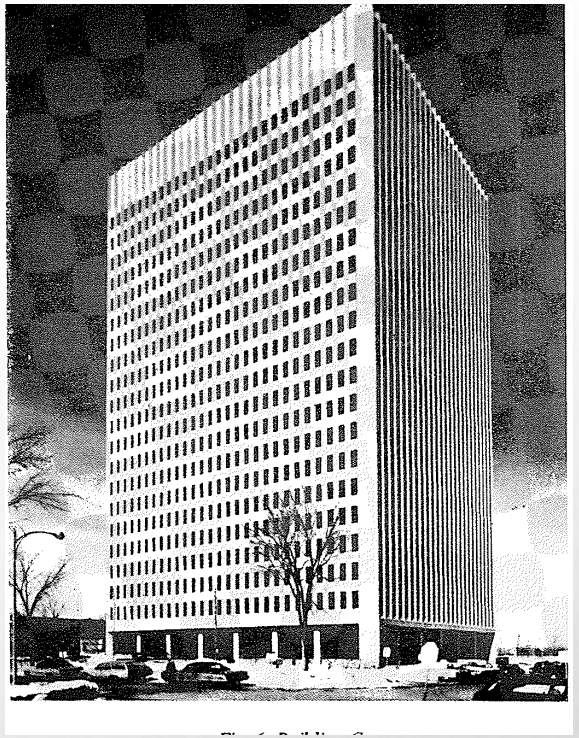
PRESENTATION OVERVIEW

- IMPACTS OF AIR LEAKAGE IN COMMERCIAL BUILDINGS
- INTERACTIONS BETWEEN AIR LEAKAGE AND INDOOR ENVIRONMENTAL QUALITY (IEQ)
- USING AEROSOLS TO SEAL AIR LEAKAGE REMOTELY
  - DUCTS
  - ENVELOPE
- AEROSOL DUCT SEALING – **JOE ST. PIERRE**
  - HOW IT WORKS
  - FAQS
  - APPLICATION EXAMPLES

UNCONTROLLED AIR FLOWS IN BUILDINGS

BUILDING ENVELOPE LEAKAGE

- DEFEATS DESIRE TO THERMALLY CONDITION AND FILTER VENTILATION AIR
- CREATES OFF-DESIGN LOADS IN PARTICULAR ZONES (E.G. COLD AIR ENTRY IN THE WINTER)
- WASTES ENERGY DUE TO CONDITIONING OF INFILTRATING AIR THAT CANNOT BE COUNTED FOR VENTILATION



DUCT LEAKAGE

- WASTES ENERGY DUE TO INCREASED FAN POWER TO MOVE UNDELIVERED AIR
- WASTES ENERGY DUE TO THERMAL EXCHANGE WITH UN-CONDITIONED SPACES
- PRODUCES INADEQUATE DILUTION OF INTERNAL POLLUTANTS

AIR FLOW CONTROL IN HOSPITALS

DUCT LEAKAGE

» MAKES IT DIFFICULT TO PROVIDE DESIGN FLOWS

» MAKES IT DIFFICULT TO PROVIDE FLOWS REQUIRED FOR PRESSURE CONTROL

BUILDING ZONE LEAKAGE

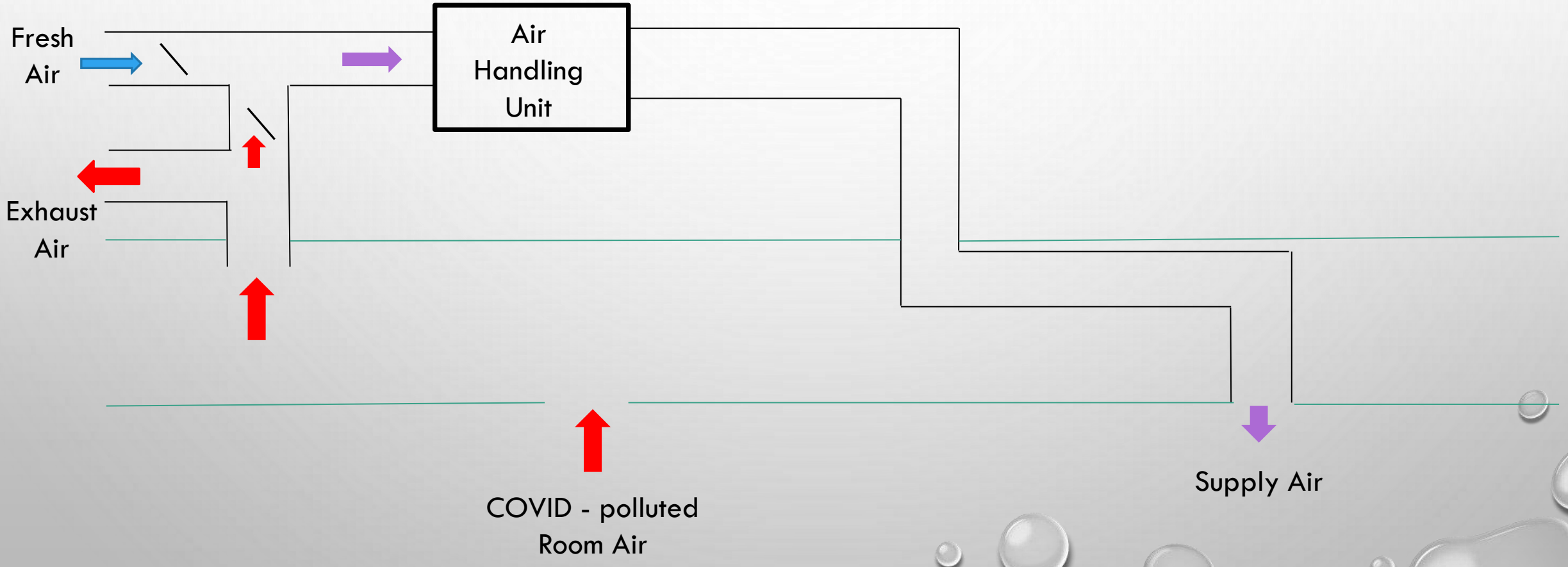
- MAKES IT DIFFICULT TO CONTROL PRESSURES IN BUILDING ZONES
  - PRESSURIZED OPERATING ROOMS
  - DEPRESSURIZED CONTAGIOUS DISEASE ROOMS

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

- **KEY GOAL:** LIMIT EXPOSURE TO BELOW INFECTIOUS DOSE
  - LIMIT QUANTITY OF VIABLE VIRAL MATERIAL ENTERING YOUR BODY
- VIRUS CONCENTRATION REDUCTION IN INDOOR AIR
  - FILTRATION
  - DESTRUCTION
  - **DILUTION**

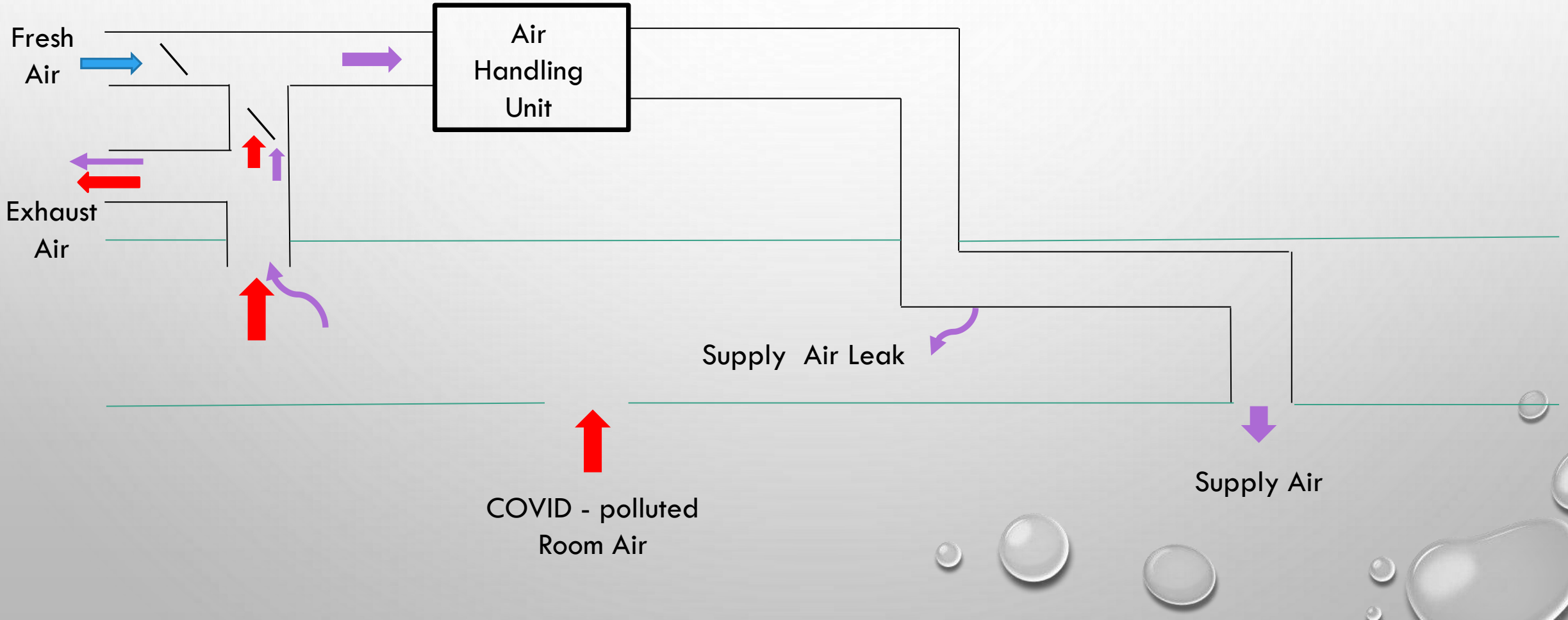
MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

SUPPLY AIR



MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

SUPPLY AIR WITH DUCT LEAKAGE



MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE

- SHORT-CIRCUITING OF FRESH AIR TO RETURN/EXHAUST AIR
- SOME FRACTION OF FRESH AIR NEVER GETS TO CONDITIONED SPACE
  - SHORT CIRCUITED AIR SENT BACK TO SUPPLY FAN OR EXHAUSTED FROM THE BUILDING
  - FRACTION EXHAUSTED DEPENDS UPON OUTDOOR AIR FRACTION AND/OR NEED FOR BUILDING PRESSURIZATION/DEPRESSURIZATION
- VIEWED ANOTHER WAY, DUCT LEAKAGE **REDUCES THE CONCENTRATION OF COVID-19 IN THE EXHAUST AIR**

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE – EXAMPLE CALCULATION

- **ASSUMPTIONS**
  - **20% DUCT LEAKAGE** AT FULL LOAD (10% UPSTREAM OF VAV BOXES, 10% DOWNSTREAM)
  - **UPSTREAM LEAKAGE FLOW IS CONSTANT** (ΔP IS CONSTANT)
  - **DOWNSTREAM LEAKAGE FRACTION IS CONSTANT** (LEAKAGE $\sim \Delta P^{0.6}$, FLOW $\sim \Delta P^{0.5}$)
    - ⇨ 30% LEAKAGE AT 50% LOAD (I.E. 50% FLOW)
  - **FIXED VENTILATION AIR FLOWRATE** - 20% OUTDOOR AIR AT FULL LOAD
    - ⇨ 40% OUTDOOR AIR AT 50% LOAD

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE – EXAMPLE CALCULATION

- FRACTION OF OUTDOOR AIR REACHING THE SPACE

  (1-LEAK FRACTION) * (1+(LEAK FRACTION)(1-OUTDOOR-AIR FRACTION))

- ANALYSIS – **FULL LOAD**

  = (1-0.2) * (1+(0.2)(1-0.2)) = 0.8*(1+0.2(0.8)) = **93% OF OA REACHES ROOM**

- ANALYSIS – **50% LOAD**

  = (1-0.3) * (1+(0.3)(1-0.4)) = 0.7*(1+0.3(0.6)) = **83% OF OA REACHES ROOM**

MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

ENERGY IMPLICATIONS OF SUPPLY DUCT LEAKAGE

- ANALYSIS – **FULL LOAD**

  93% OF OA REACHES ROOM ⇨ NEED TO MOVE (1/0.93-1) = 8% MORE AIR ⇨

  20% MORE FAN ENERGY TO GET SAME OUTDOOR AIR AS AIRTIGHT SYSTEM

- ANALYSIS – **50% LOAD**

  83% OF OA REACHES ROOM ⇨ NEED TO MOVE (1/0.83-1) = 21% MORE AIR ⇨

  58% MORE FAN ENERGY TO GET SAME OUTDOOR AIR AS AIRTIGHT SYSTEM

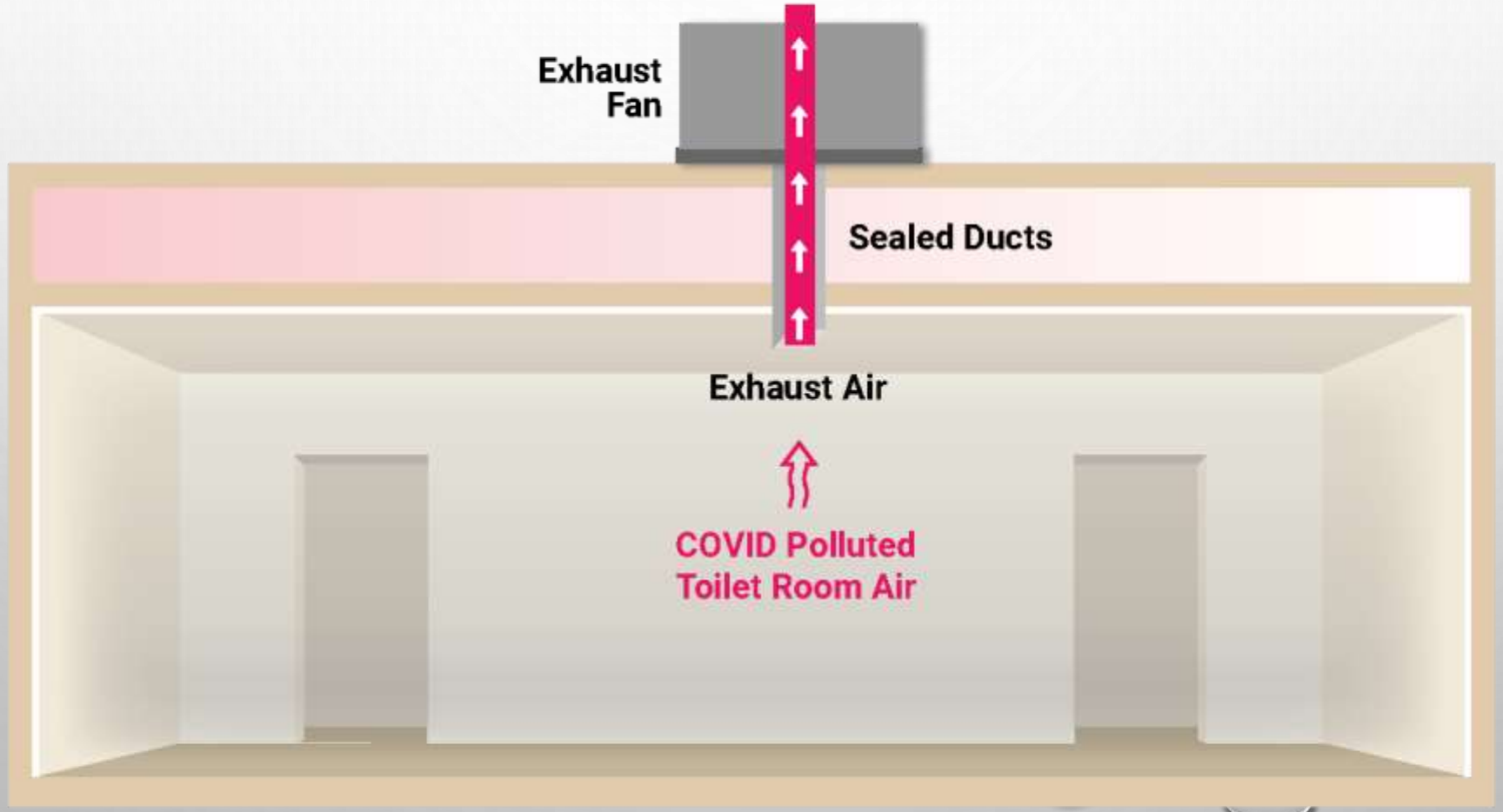
MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

IMPLICATIONS OF SUPPLY DUCT LEAKAGE

- FRACTION OF VENTILATION AIR REACHING THE SPACE IS LOWER AT PART LOAD
- FRACTION OF VENTILATION AIR REACHING THE SPACE IS LOWER AT HIGHER OUTDOOR AIR FRACTIONS
- ACHIEVING THE DESIRED OUTDOOR AIR FLOWRATES TO THE SPACES REQUIRES MOVING MORE AIR AT THE FAN
- MOVING MORE AIR REQUIRES MORE ENERGY CONSUMPTION
- ALTERNATIVE IS TO EXPERIENCE HIGHER COVID-19 CONCENTRATIONS

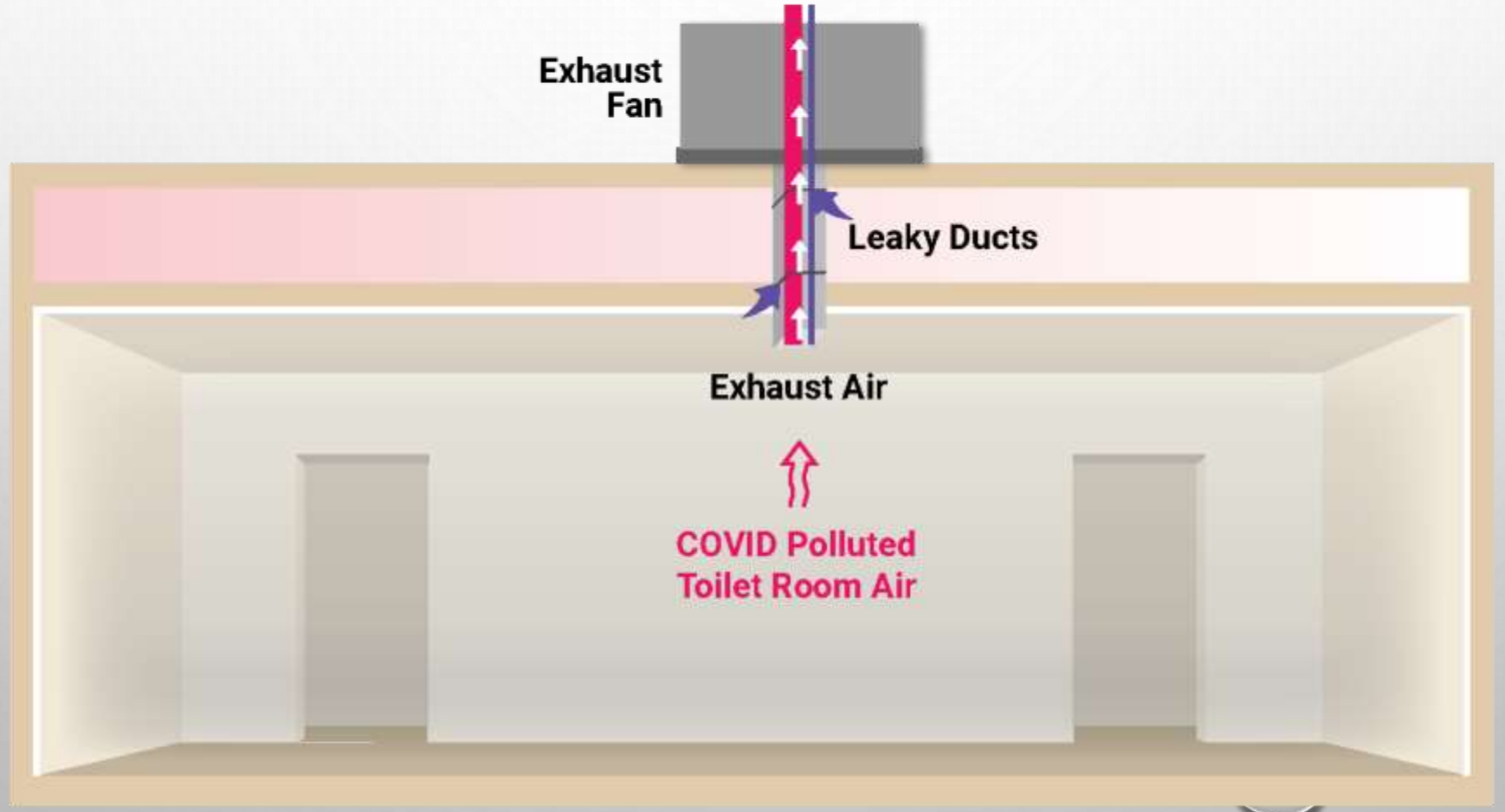
MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

EXHAUST DUCT WITHOUT LEAKAGE



MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

EXHAUST DUCT WITH LEAKAGE



MANAGING COVID-19 TRANSMISSION IN INDOOR ENVIRONMENTS

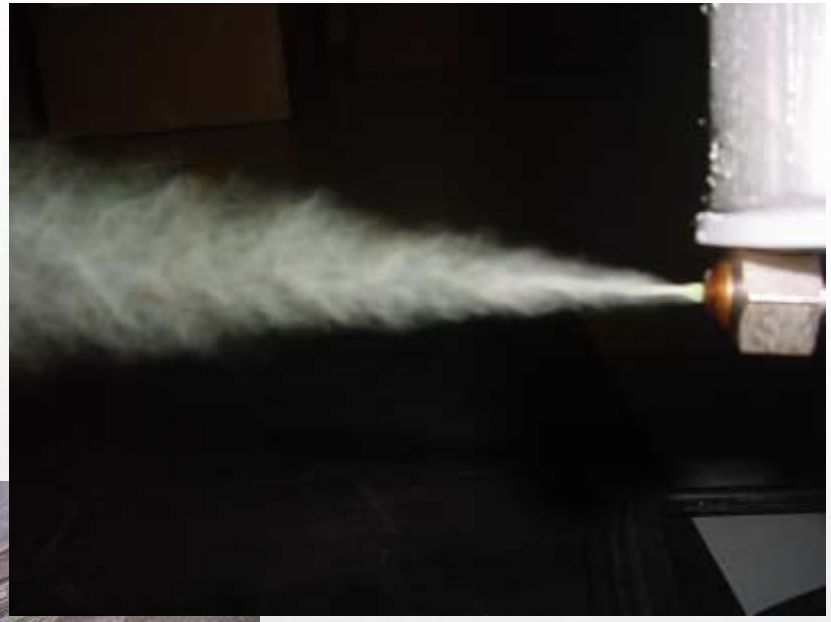
IMPLICATIONS OF EXHAUST DUCT LEAKAGE

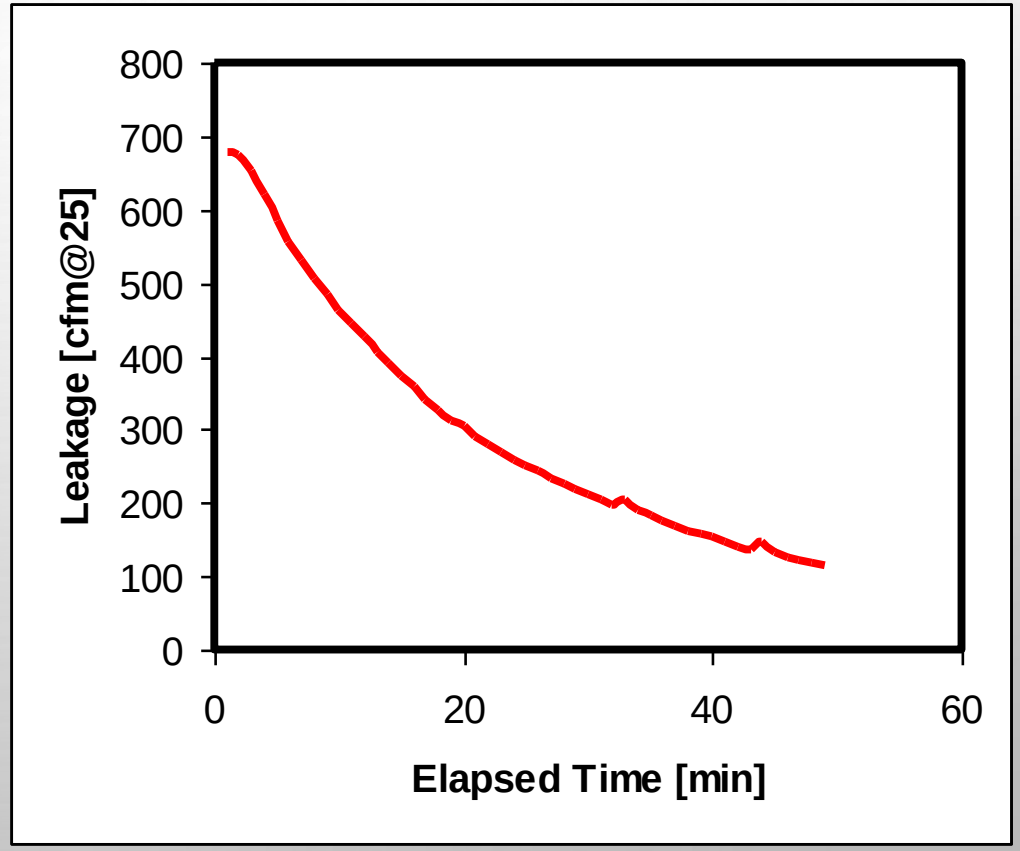
- **EXHAUST DUCT LEAKAGE REDUCES EXTRACTION OF COVID-19 FROM INTERIOR ZONES**
- NEED TO INCREASE FAN FLOW TO GET SAME EXTRACTION
- FAN POWER GOES ROUGHLY WITH CUBE OF FLOW RATE
  - **20% LEAKAGE** MEANS 25% MORE FLOW ⇨ **95% MORE FAN POWER**
- MOST OF THE TIME THIS ENERGY IMPLICATION WILL NOT BE REALIZED
  - FAN CANNOT KEEP UP
  - EXTRACTION IS LOWER

MEASURED EXHAUST SYSTEM LEAKAGE (U.S.)

Building	Fan Flow [cfm]	Leakage [%]	Notes
Condominium (40-Story)	950	74%	Building-Cavity Bathroom Exhaust
NYS University Dorm (10-story)	2,300	70%	Bath/Shower Exhaust
NYS University Dorm (7-story)	2,050	54%	Bath/Shower Exhaust
Navy BEQ (10-story dorm)	6,300	18%	Ducted Supply w/heat wheel
Navy BEQ (10-story dorm)	6,470	54%	Building-Cavity Exhaust w/heat wheel
Barracks (8 3-story buildings)	20,000	20%	Bath/Shower Exhaust
Office Toilet Exhaust (3-story)	8,700	9%	No pre-qualification of leakage
Hospital Exhaust (9-story)	8,200	19%	Sterilization room riser
Seven NYC Apartment Exhausts	**2,450**	**36%**	**Kitchen/Bath Exhausts**
AVERAGE		**39%**	

ONE EXISTING-BUILDING OPTION - REMOTE SEALING OF DUCTS WITH AEROSOLIZED SEALANT





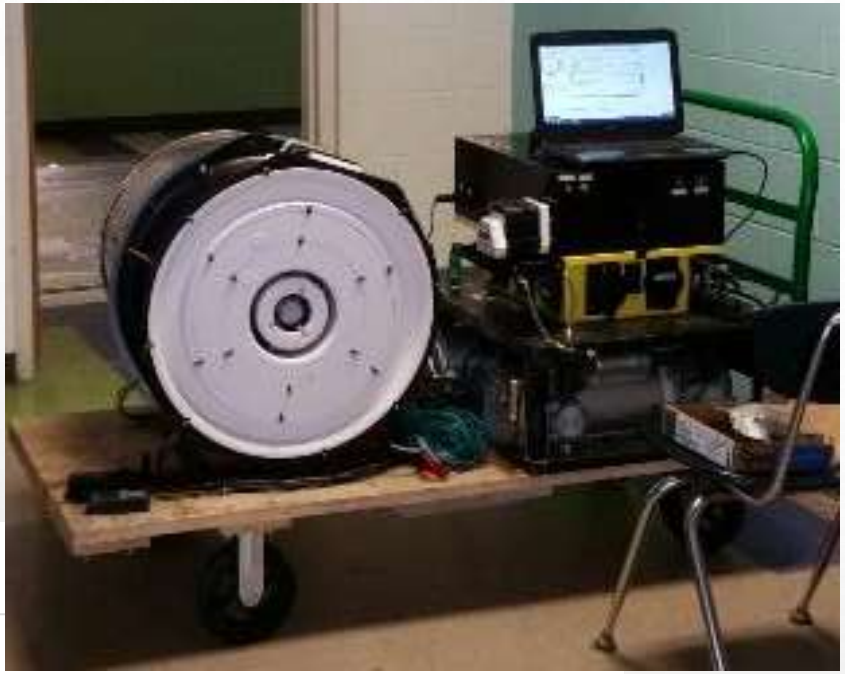
AEROSOL BUILDING SEALING TECHNOLOGY

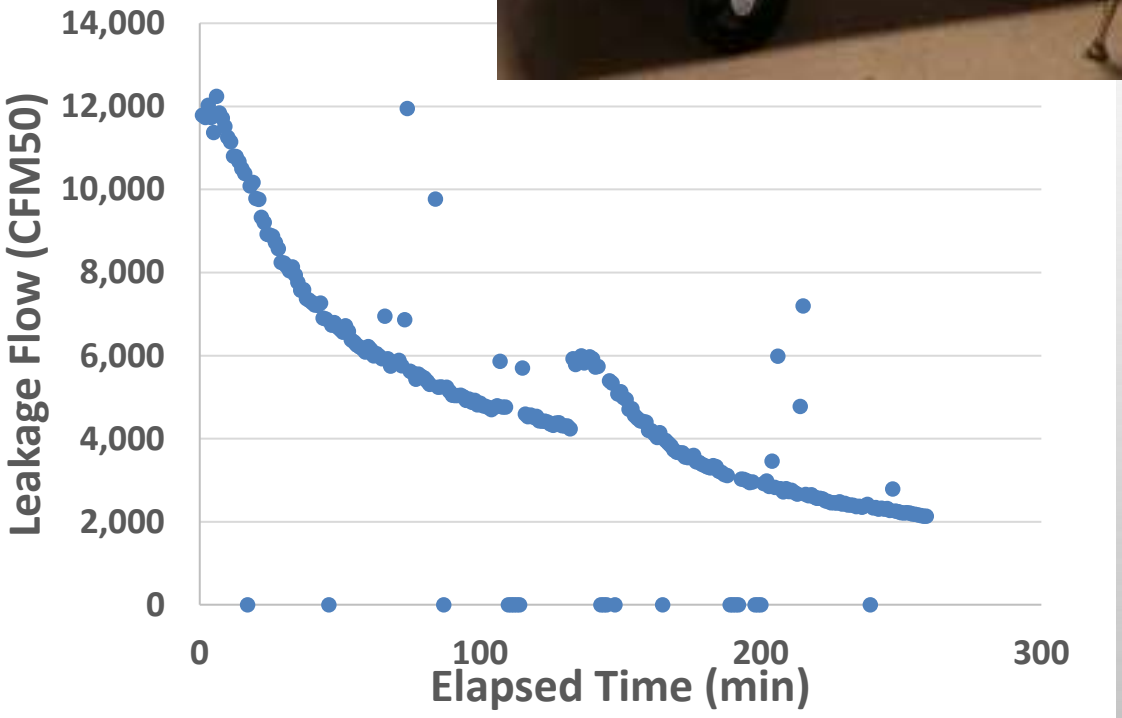
BASIC CONCEPT

- USE BLOWER DOOR TO PRESSURIZE ZONE TO BE SEALED
- FOG ZONE WITH AEROSOLIZED SEALANT PARTICLES
- UTILIZE SEALANT MATERIAL WITH NO RESIDUAL TACK

POST-SHEETROCK AEROSOL-SEALED LEAKS

AEROSOL BUILDING SEALING TECHNOLOGY – DOD BUILDINGS





REMOTE SEALING OF BUILDING ZONES WITH AEROSOLIZED SEALANT

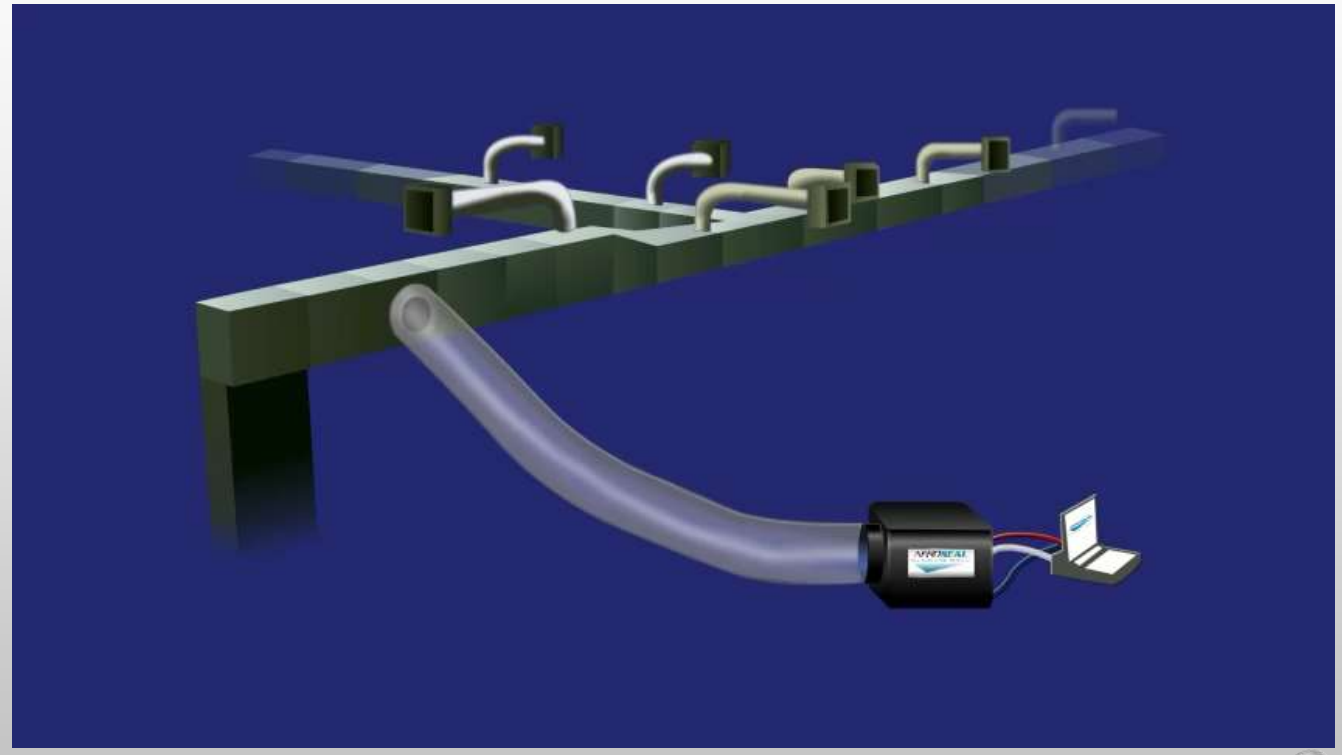
- **NEW APPLICATION BEING EXPLORED – SEALING LEAKS BETWEEN CEILING PLENUM RETURN AND OUTDOORS**
  - PRESSURIZE ROOM WITH A BLOWER DOOR
  - PLACE INJECTORS ABOVE THE CEILING TILES
  - SEALANT CONTROLLED BY AIR FLOW FROM ROOM TO CEILING PLENUM

AEROSOL SEALING PROCESS

JOE ST. PIERRE
SALES/PROJECT MANAGER - AIRWAYS SYSTEMS, INC

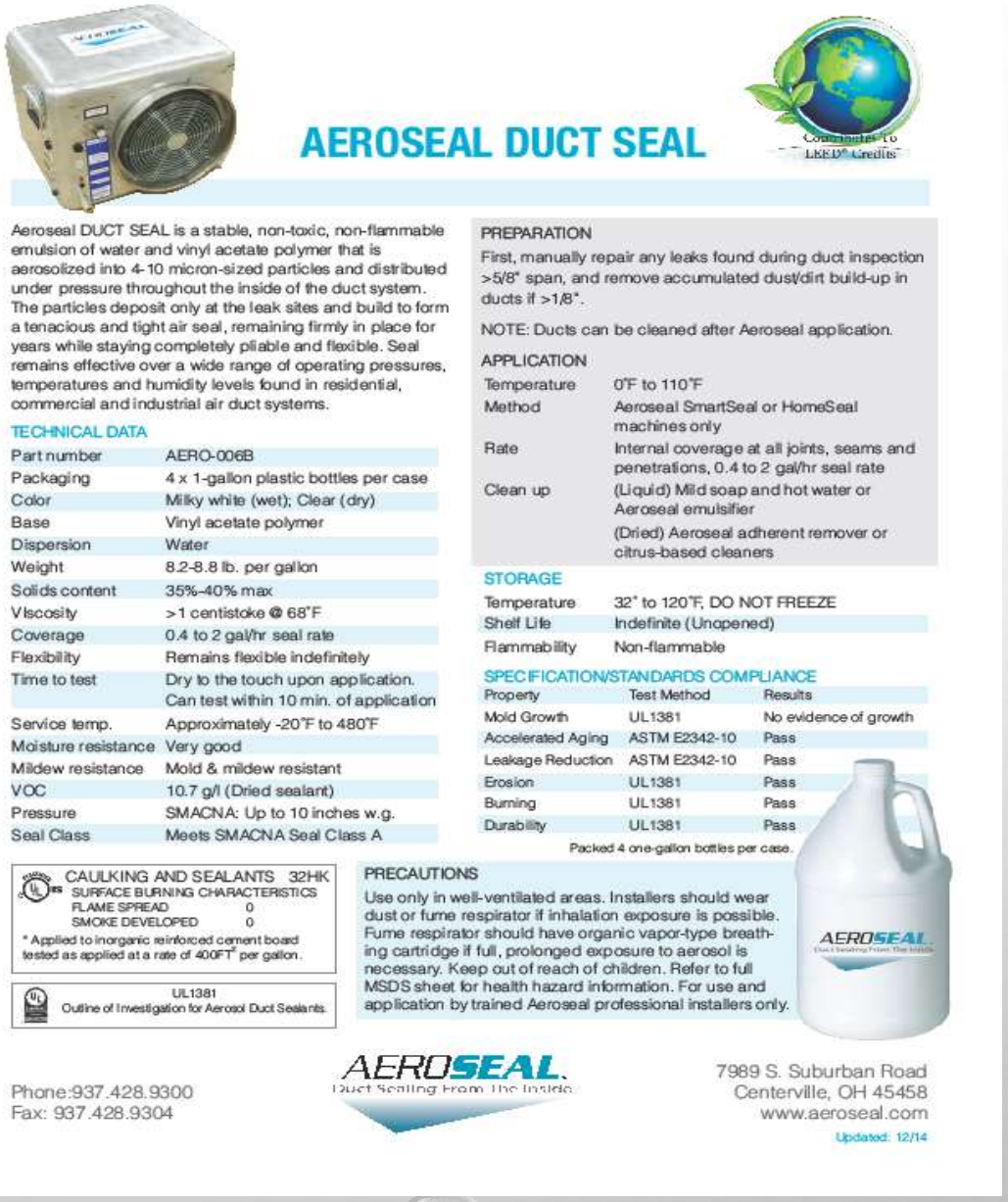
AEROSOL SEALING PROCESS

- CUT ACCESS HOLES
- ISOLATE FAN(S)
- BLOCK DIFFUSERS, VAV'S, COILS, ETC.
- CONNECT INJECTION EQUIPMENT
- PRE-SEAL TEST (BASELINE)
- INJECT ATOMIZED SEALANT
- POST-SEAL: MEASURE FINAL LEAKAGE
- PRESENT FINAL CERTIFICATE(S)



DUCT SEALANT

- VINYL POLYMER
- REMAINS FLEXABLE
- NO OFFGASSING
- UL 1381
  - MOLD GROWTH
  - EROSION
  - FLAME SPREAD
  - DURABILITY



AEROSEAL DUCT SEAL

Aeroseal DUCT SEAL is a stable, non-toxic, non-flammable emulsion of water and vinyl acetate polymer that is aerosolized into 4-10 micron-sized particles and distributed under pressure throughout the inside of the duct system. The particles deposit only at the leak sites and build to form a tenacious and tight air seal, remaining firmly in place for years while staying completely pliable and flexible. Seal remains effective over a wide range of operating pressures, temperatures and humidity levels found in residential, commercial and industrial air duct systems.

TECHNICAL DATA

Part number	AERO-006B
Packaging	4 x 1-gallon plastic bottles per case
Color	Milky white (wet); Clear (dry)
Base	Vinyl acetate polymer
Dispersion	Water
Weight	8.2-8.8 lb. per gallon
Solids content	35%-40% max
Viscosity	>1 centistoke @ 68°F
Coverage	0.4 to 2 gal/hr seal rate
Flexibility	Remains flexible indefinitely
Time to test	Dry to the touch upon application. Can test within 10 min. of application
Service temp.	Approximately -20°F to 480°F
Moisture resistance	Very good
Mildew resistance	Mold & mildew resistant
VOC	10.7 g/l (Dried sealant)
Pressure	SMACNA: Up to 10 inches w.g.
Seal Class	Meets SMACNA Seal Class A

CAULKING AND SEALANTS 32HK
SURFACE BURNING CHARACTERISTICS
FLAME SPREAD 0
SMOKE DEVELOPED 0
* Applied to inorganic reinforced cement board tested as applied at a rate of 400FT² per gallon.

UL1381
Outline of Investigation for Aerosol Duct Sealants.

PREPARATION

First, manually repair any leaks found during duct inspection >5/8" span, and remove accumulated dust/dirt build-up in ducts if >1/8".

NOTE: Ducts can be cleaned after Aeroseal application.

APPLICATION

Temperature	0°F to 110°F
Method	Aeroseal SmartSeal or HomeSeal machines only
Rate	Internal coverage at all joints, seams and penetrations, 0.4 to 2 gal/hr seal rate
Clean up	(Liquid) Mild soap and hot water or Aeroseal emulsifier
	(Dried) Aeroseal adherent remover or citrus-based cleaners

STORAGE

Temperature	32° to 120°F, DO NOT FREEZE
Shelf Life	Indefinite (Unopened)
Flammability	Non-flammable

SPECIFICATION/STANDARDS COMPLIANCE

Property	Test Method	Results
Mold Growth	UL1381	No evidence of growth
Accelerated Aging	ASTM E2342-10	Pass
Leakage Reduction	ASTM E2342-10	Pass
Erosion	UL1381	Pass
Burning	UL1381	Pass
Durability	UL1381	Pass

Packed 4 one-gallon bottles per case.

PRECAUTIONS

Use only in well-ventilated areas. Installers should wear dust or fume respirator if inhalation exposure is possible. Fume respirator should have organic vapor-type breathing cartridge if full, prolonged exposure to aerosol is necessary. Keep out of reach of children. Refer to full MSDS sheet for health hazard information. For use and application by trained Aeroseal professional installers only.

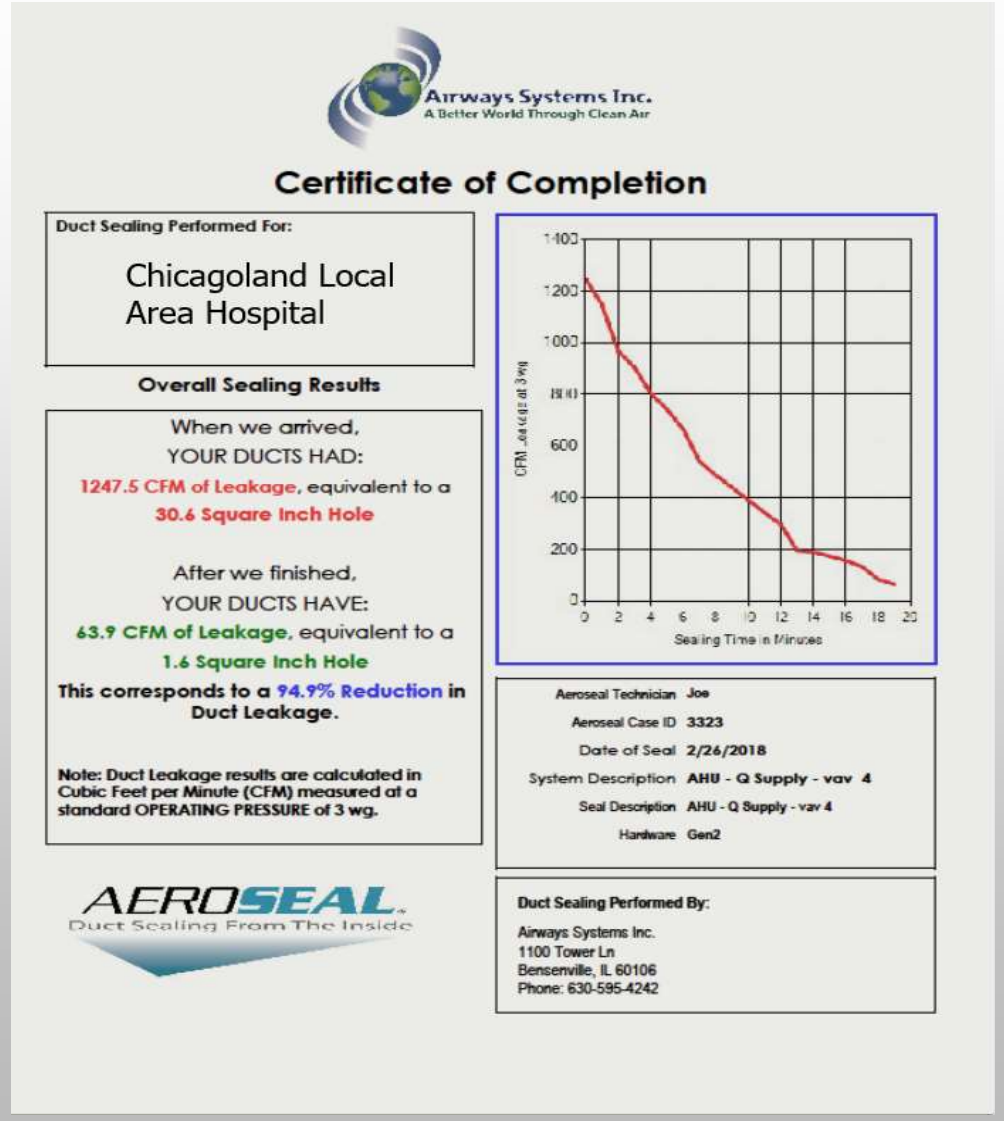
Phone:937.428.9300
Fax: 937.428.9304

AEROSEAL
Duct Sealing From The Inside

7989 S. Suburban Road
Centerville, OH 45458
www.aeroseal.com

Updated: 12/14

CERTIFICATE OF COMPLETION



Airways Systems Inc.
A Better World Through Clean Air

Certificate of Completion

Duct Sealing Performed For:

Chicagoland Local Area Hospital

Overall Sealing Results

When we arrived,
YOUR DUCTS HAD:
1247.5 CFM of Leakage, equivalent to a
30.6 Square Inch Hole

After we finished,
YOUR DUCTS HAVE:
63.9 CFM of Leakage, equivalent to a
1.6 Square Inch Hole

This corresponds to a 94.9% Reduction in Duct Leakage.

Note: Duct Leakage results are calculated in Cubic Feet per Minute (CFM) measured at a standard OPERATING PRESSURE of 3 wg.

Aeroseal Technician	Joe
Aeroseal Case ID	3323
Date of Seal	2/26/2018
System Description	AHU - Q Supply - vav 4
Seal Description	AHU - Q Supply - vav 4
Hardware	Gen2

AEROSEAL
Duct Sealing From The Inside

Duct Sealing Performed By:

Airways Systems Inc.
1100 Tower Ln
Bensenville, IL 60106
Phone: 630-595-4242

When we arrived
YOUR DUCTS HAD:
1,247.5 CFM of Leakage equivalent

After we finished
YOUR DUCTS HAVE
63.9 CFM of Leakage equivalent

This corresponds to a **94.9%**
Reduction in Duct Leakage

LOCAL AREA HOSPITAL

GOAL

MEET DESIGN FLOW AT GRILLES FOR A BRONCHOSCOPY LAB

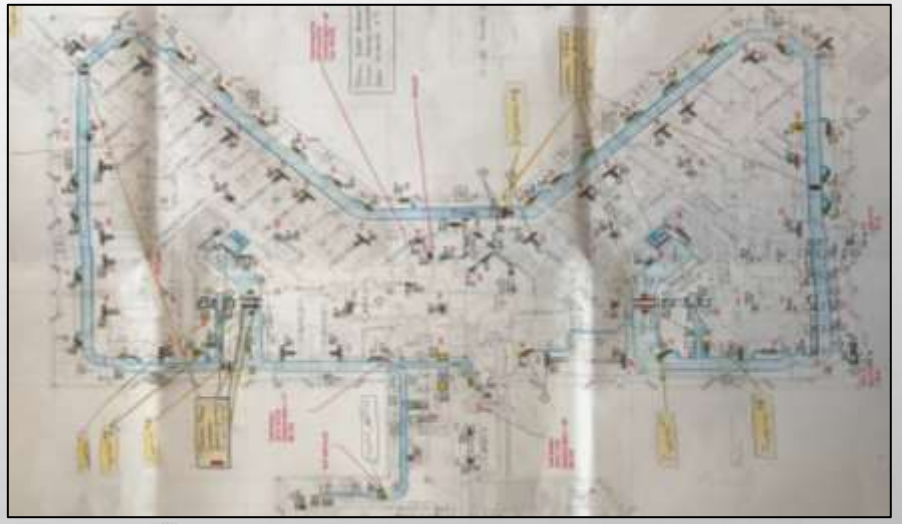
- CLEANED/SEALED EXHUAST RISERS
- INITIAL LEAKAGE 514 CFM
- POST LEAKAGE 33 CFM
- LEAKAGE REDUCTION 94%
- COMPLETED IN 1DAY

LOCAL AREA HOSPITAL

GOAL

IMPROVE AIR DISTRIBUTION IN A PATIENT WING

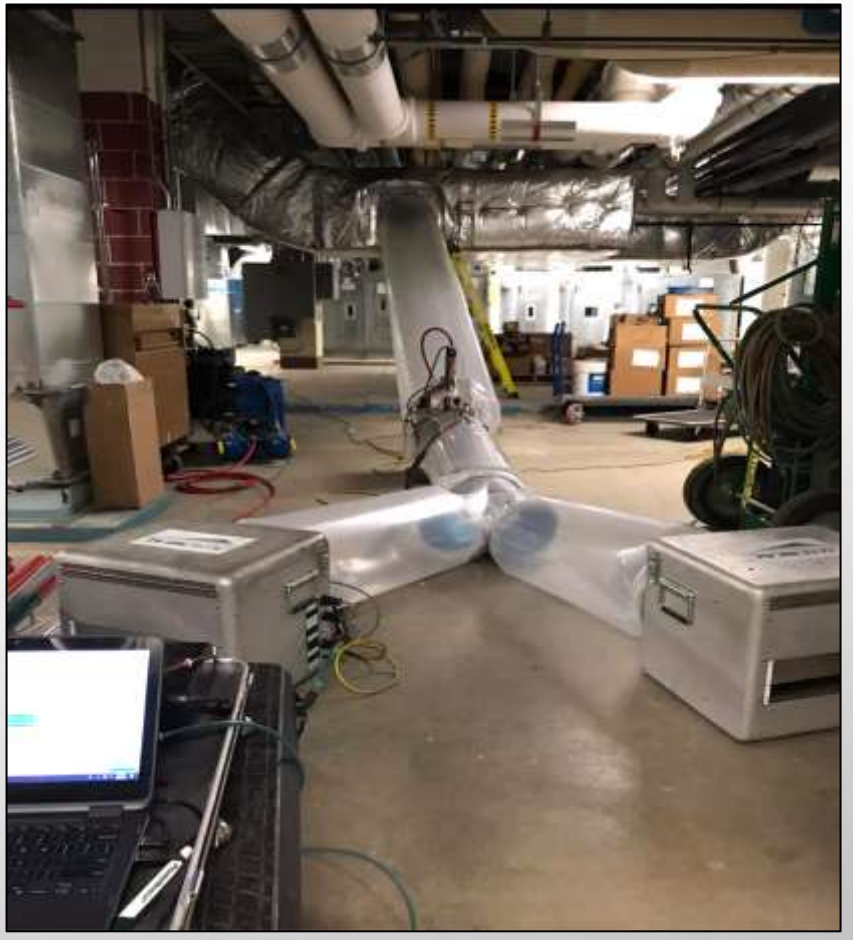
- CLEANED/SEALED OVER 500’ DUCT
- 7 SEPARATE INJECTIONS
- MET DESIGN AT DIFFUSERS
- INITIAL LEAKAGE 1,867 CFM
- POST LEAKAGE 230 CFM
- REDUCTION 97.6%
- COMPLETED IN 2 DAYS



LOCAL AREA HOSPITAL

GOAL

- IMPROVE AIR DISTRIBUTION OVER 7 AHU'S (TOTAL FAN DESIGN 152,700)
  - INITIAL LEAKAGE 20,646 CFM
  - POST LEAKAGE 845 CFM
  - RECOVERED 19,801 CFM (49.50 COOLING TONS)
  - REDUCTION 95.9%



CASE STUDY

University of Ottawa's Heart Institute

<u>GOAL</u>

- Eliminate duct leakage as a cause of building-to-building air contamination
  - Initial Leakage 800 CFM
  - Post Leakage 10 CFM

PROJECT OVERVIEW

BUILDING
University of Ottawa Heart Institute

LOCATION
Ottawa, Ontario

ENGINEER
GENIVAR | Constructive People

DUCT SPECIALISTS
AWS Technologies

GOAL
Eliminate duct leakage as cause of building-to-building air contamination

BEFORE AEROSEAL
Up to 800 CFM* of leakage

AFTER AEROSEAL
10 CFM of leakage

RESULTS
Virtually eliminated ventilation leakage; Improved system efficiency; Reduced utility costs

SEALING TECHNOLOGY FAQS

- DOES NOT COAT THE DUCTS
- VINYL POLYMER IS SAFE
- NO LINGERING ODORS OR OFF-GASSING
- LASTS 10+ YEARS
- SEALS HOLES UP TO 1/2" ACROSS
- SEALANT REMAINS RUBBERY
- NEED NOT CLEAN BEFORE SEALING, HOWEVER IT IS BETTER TO CLEAN VERY DIRTY EXHAUSTS
- CLEANING AFTER SEALING GENERALLY DOES NOT HURT SEALS

CONCLUSIONS

- **Supply or Exhaust Duct Leakage** either reduces COVID dilution or results in larger energy use (or some of each)
- **Envelope Leakage** increases air flows needed to maintain building pressure control
- **Envelope and Duct Leakage** can be addressed in existing buildings


Questions?