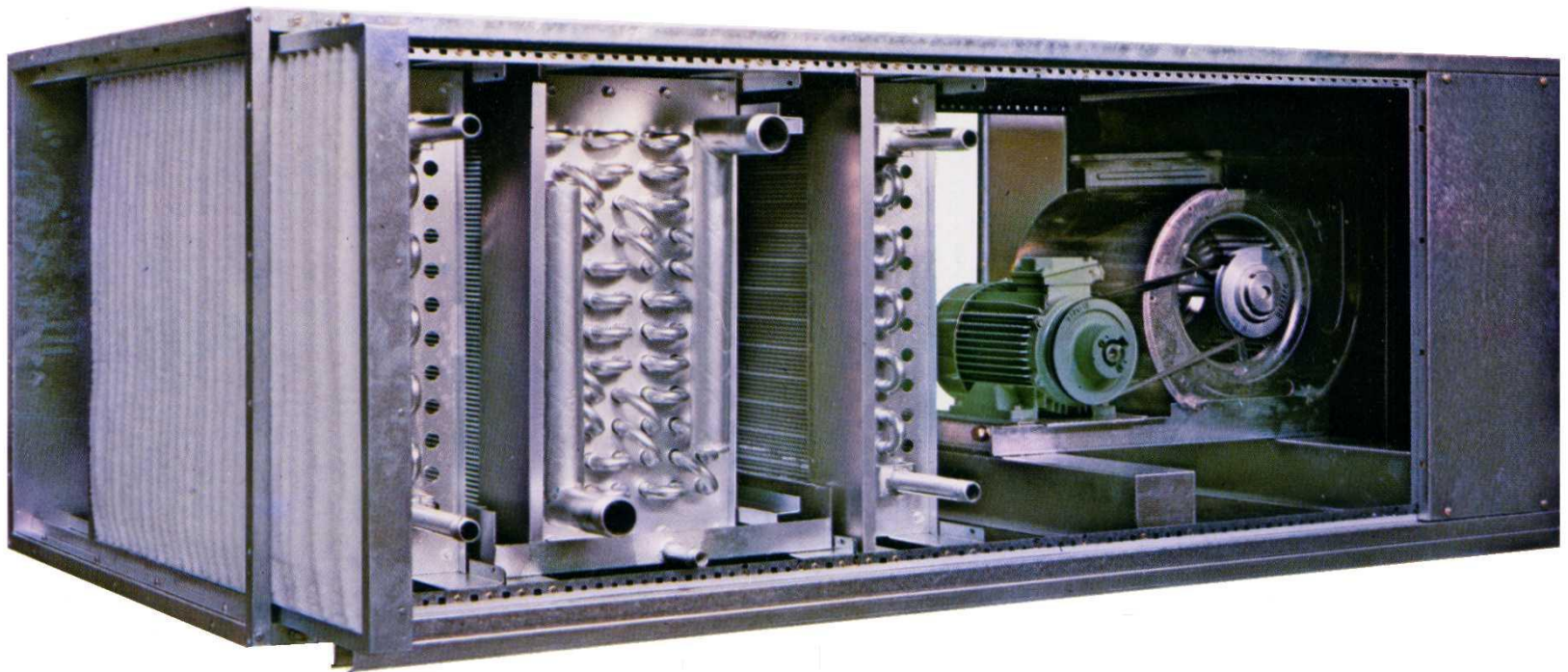


HVAC System overview & In-situ testing.



Targets of Lecture

General understanding about HVAC systems:

- Typical HVAC processes
- AHU's (Air handling units), fan coil units, exhaust fans
- In-Situ testing of air filters in an HVAC system.

What is HVAC?

- Heating, Ventilation, Air Conditioning.
- It also controls and maintain the temperature, humidity, air movement, air cleanliness in a space within predetermined limits (setting).
- Especially important in medium to large buildings, such as office towers or large manufacturing/operation facilities.
- All preferably integrated into one system.
- In warm climates usually don't require heating system.

Ventilation



- The process of "changing" or "replacing" air (fresh air) in any space to control temperature or remove moisture, smoke, carbon dioxide, etc.
- Ventilation includes both the exchange of air from the outside as well as mixing the circulation of air within the building.
- One of the most important factors is to maintain the acceptable indoor air quality (IAQ) in the building.
- Supplied air that used for ventilation is filtered, cooled and/or heated inside the air handling units.

Air conditioning



- Refers to the cooling and dehumidification of indoor air for thermal comfort.
- Air conditioning systems are designed to control the air temperature and humidity within an area or room.
- Excess heat from the circulating air is usually removed by the cooling coil that is supplied with chilled water.
- To decrease relative humidity, the circulating air needs to be cooled below its dew point temperature (compression) and then heated it back to meet the room setting requirement.

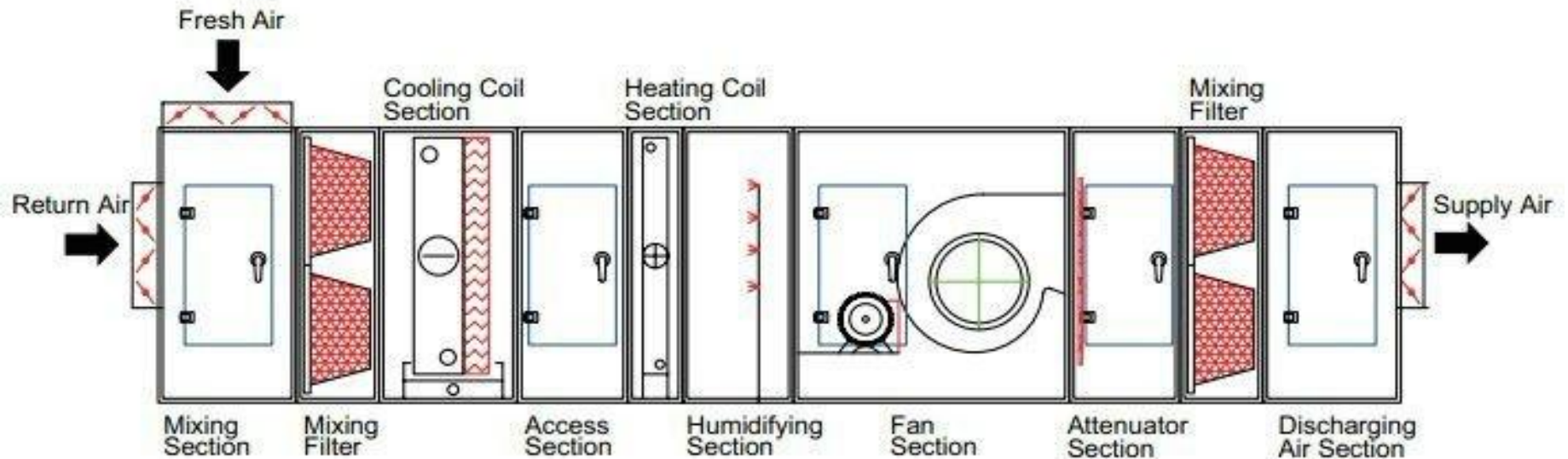
Major terms



Air handling unit (AHU) – composed of basic components such as filters bank, cooling coils and blower, arranged in sequence to condition the air, transport it and introduces it to the space that need to be condition.

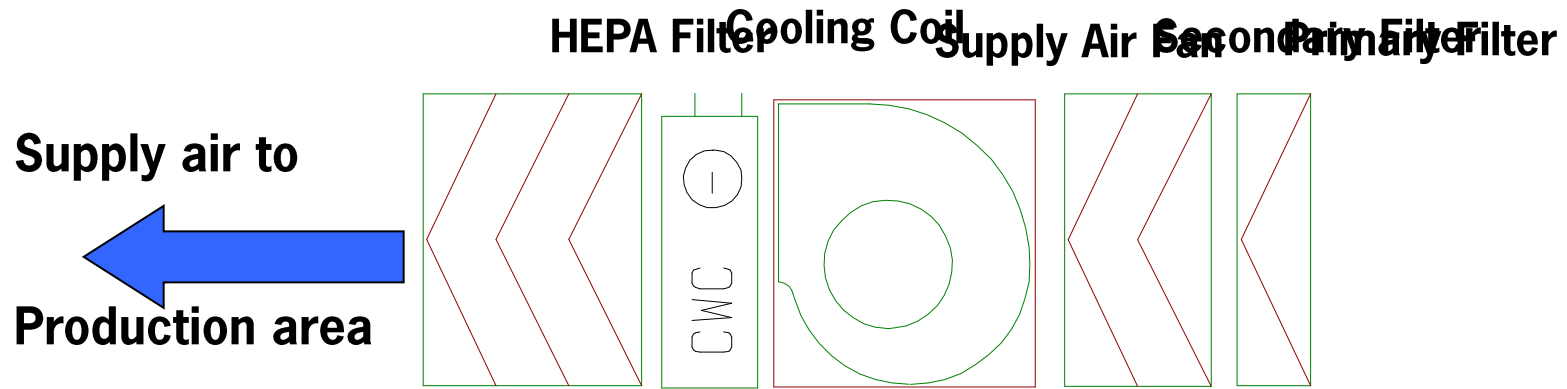
- **Chiller** – a device that removes heat through liquid. The chilled liquid flows through pipes and passes through the evaporator coils in the air handling units, FCU's, etc.
- **Coil** – components that performs heat transfer inside an AHU, FCU etc.
- **Damper** – a plate or gate installed in a duct to control or regulate the airflow.
- **Fan coil unit (FCU)** – a small terminal unit that is often composed of only a blower and a cooling coil.

A Typical Air Handling Unit (AHU)



- Air filters separate any airborne particles from air stream.
- Their purpose is to :
 - provide clean air and improved Indoor Air Quality to building occupants.
 - keep the HVAC system clean and energy efficient.

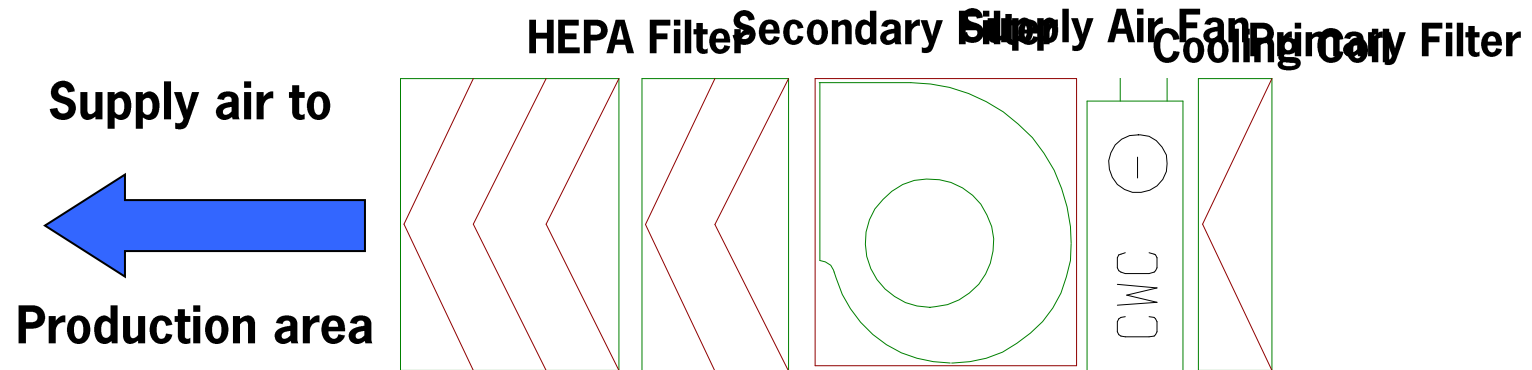
AHU Component Assembly



This looks better!

Or is it better?

AHU Component Assembly



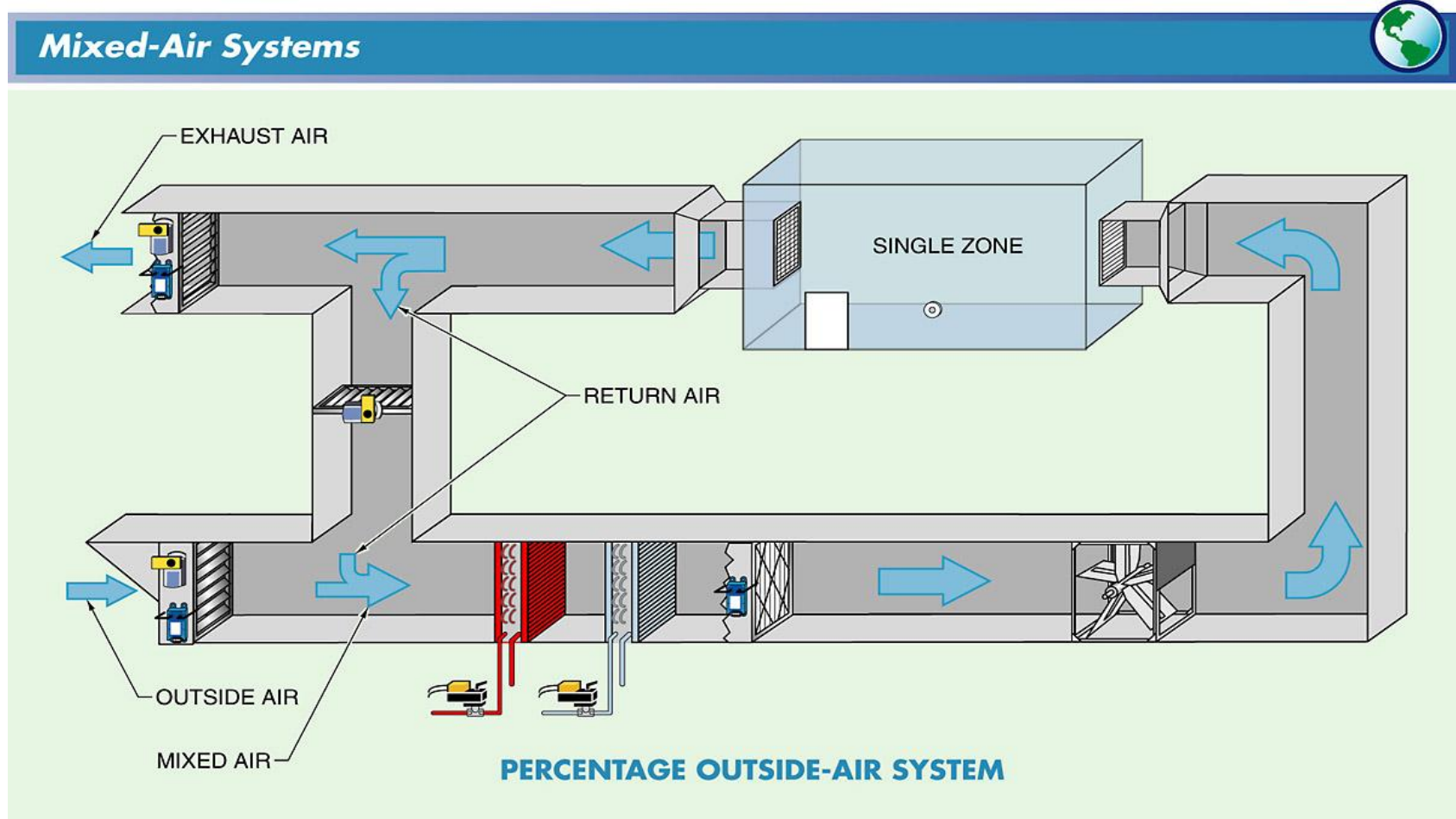
That's much better!

HEPA filter *must* be the very last component !

Typical HVAC processes – AHU

- Air handling units are used to condition the air, transport it, and introduces it to the conditioned space.
- Occasionally consists of two fans (return and supply), filters, and one or more coils for heating/cooling.
- To improve air quality, circulating air is often mixed with fresh air.
- Supply air temperature is being maintain through the mean of adjusting the thermostats setting.

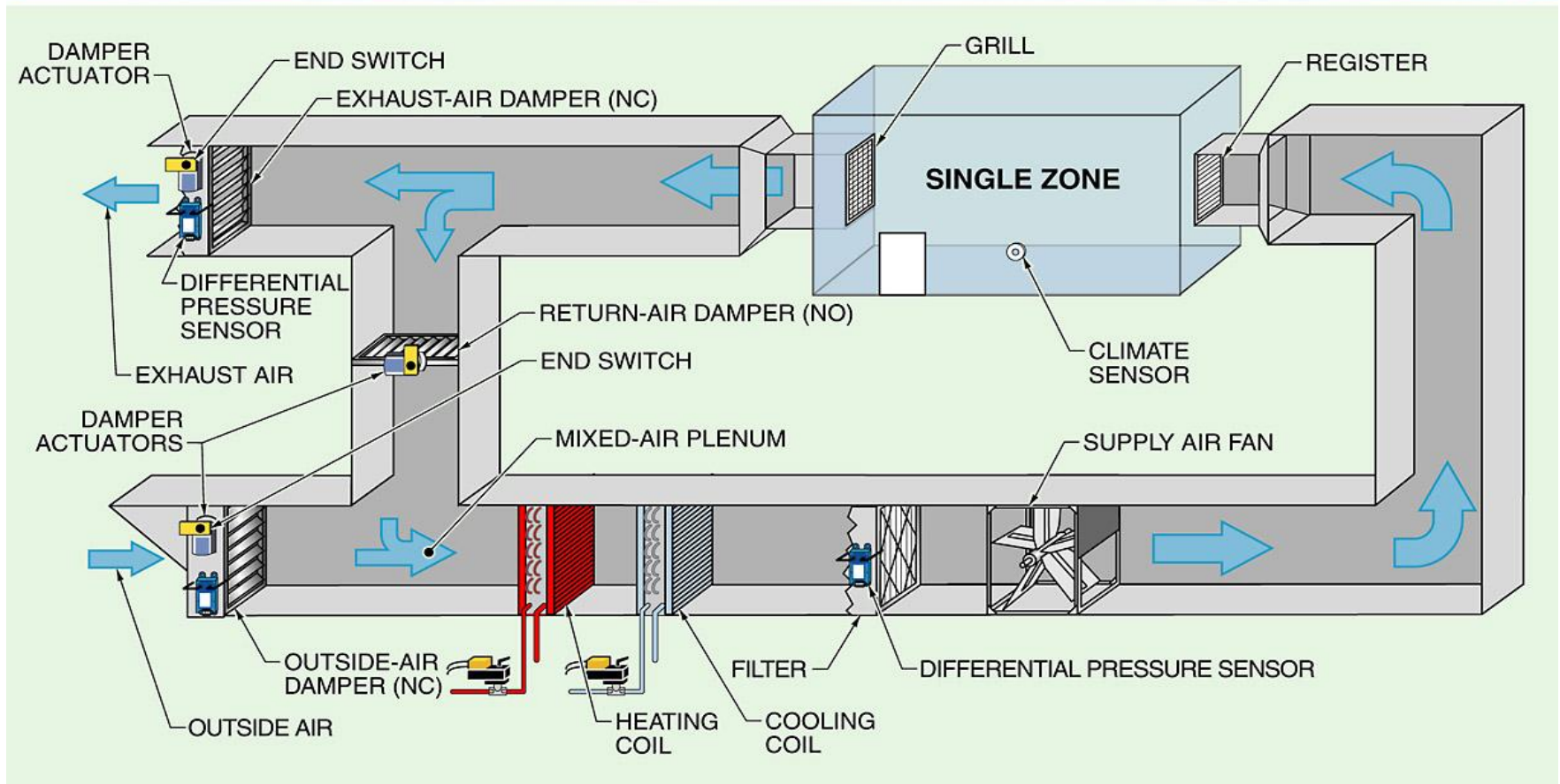
Typical HVAC processes – Mixed Air System



Mixed-air systems allow certain percentage of outside air to mix with the return air.

Typical HVAC processes – Single Zone AHU

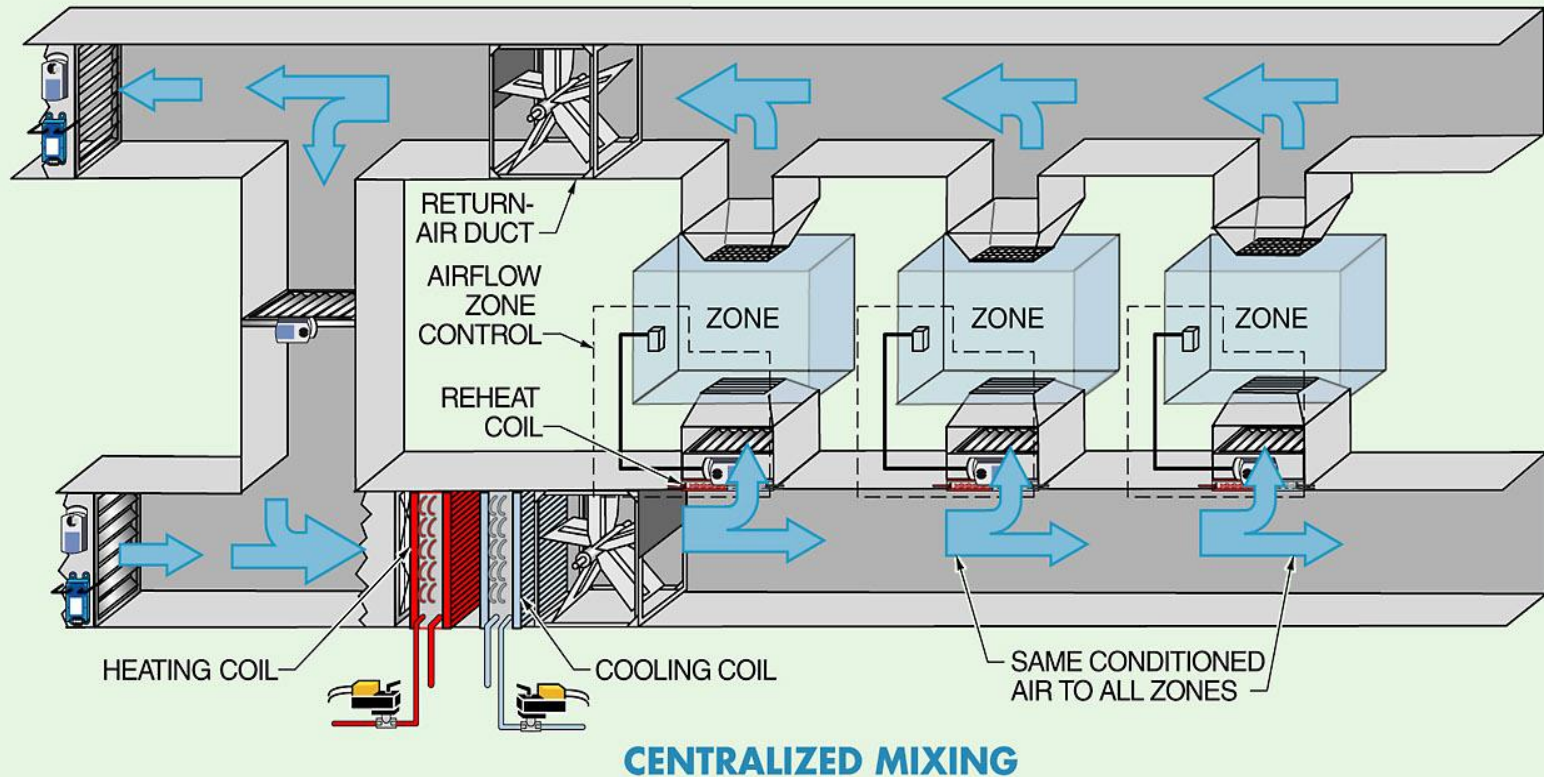
Single-Zone Air-Handling Units



Single-zone air-handling units provide conditioned air to one zone or area.

Typical HVAC processes – Multizone Zone

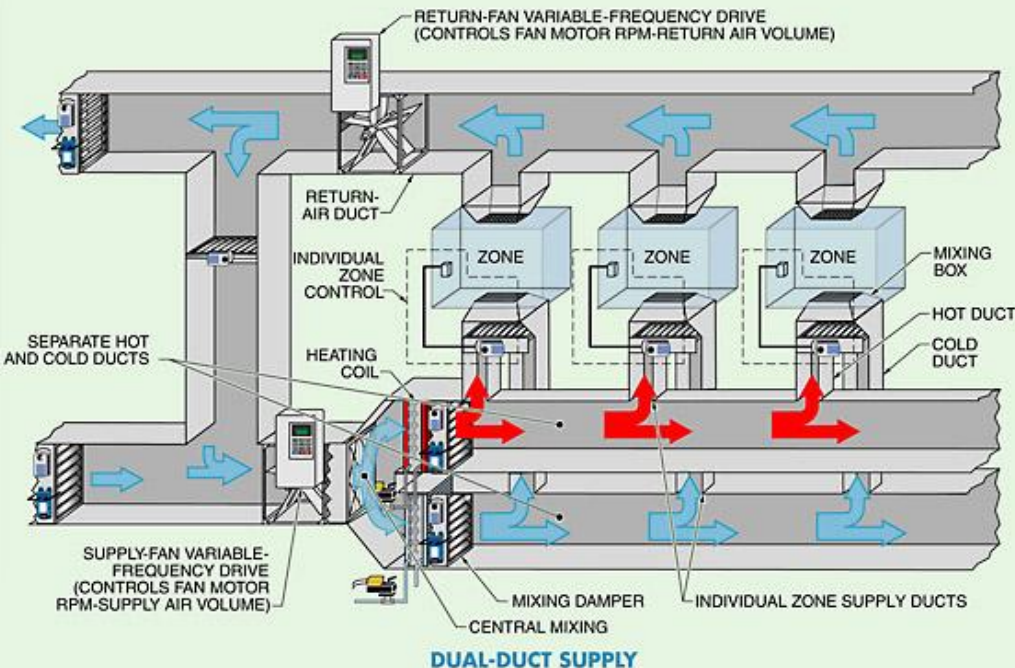
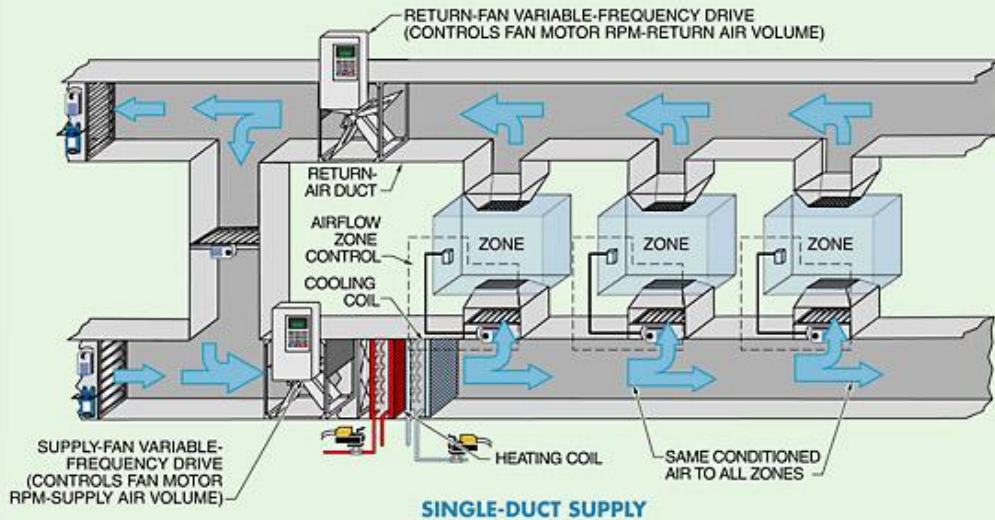
Multizone Air-Handling Units



- Multizone air-handling units use dampers to provide conditioned air to numerous of zones or area.



Typical HVAC processes – VAV AHU



- VAV air-handling units usually use a variable-frequency drive-controlled fan to vary air volumes in a duct in order to maintain the desired static pressure.

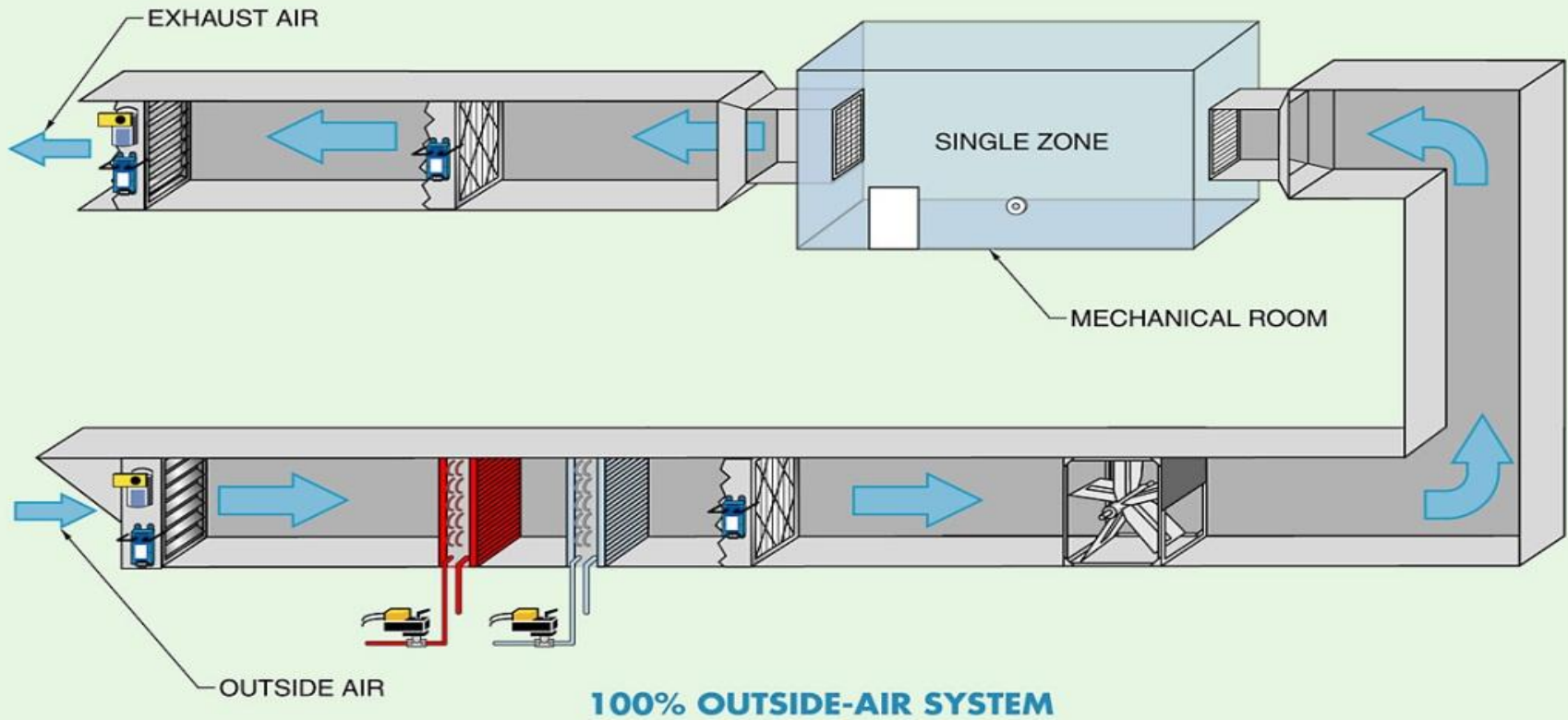
Typical HVAC processes – MAU



- Fresh air handling units are used for supplying fresh air from outside into a building.
- Indoor air quality is improved as the serving area is being “replace” with 100% fresh air.
- Usually takes more energy to heat/cool fresh air to room temperature.
- Also be used for supplying pre cooled air to FCU's.

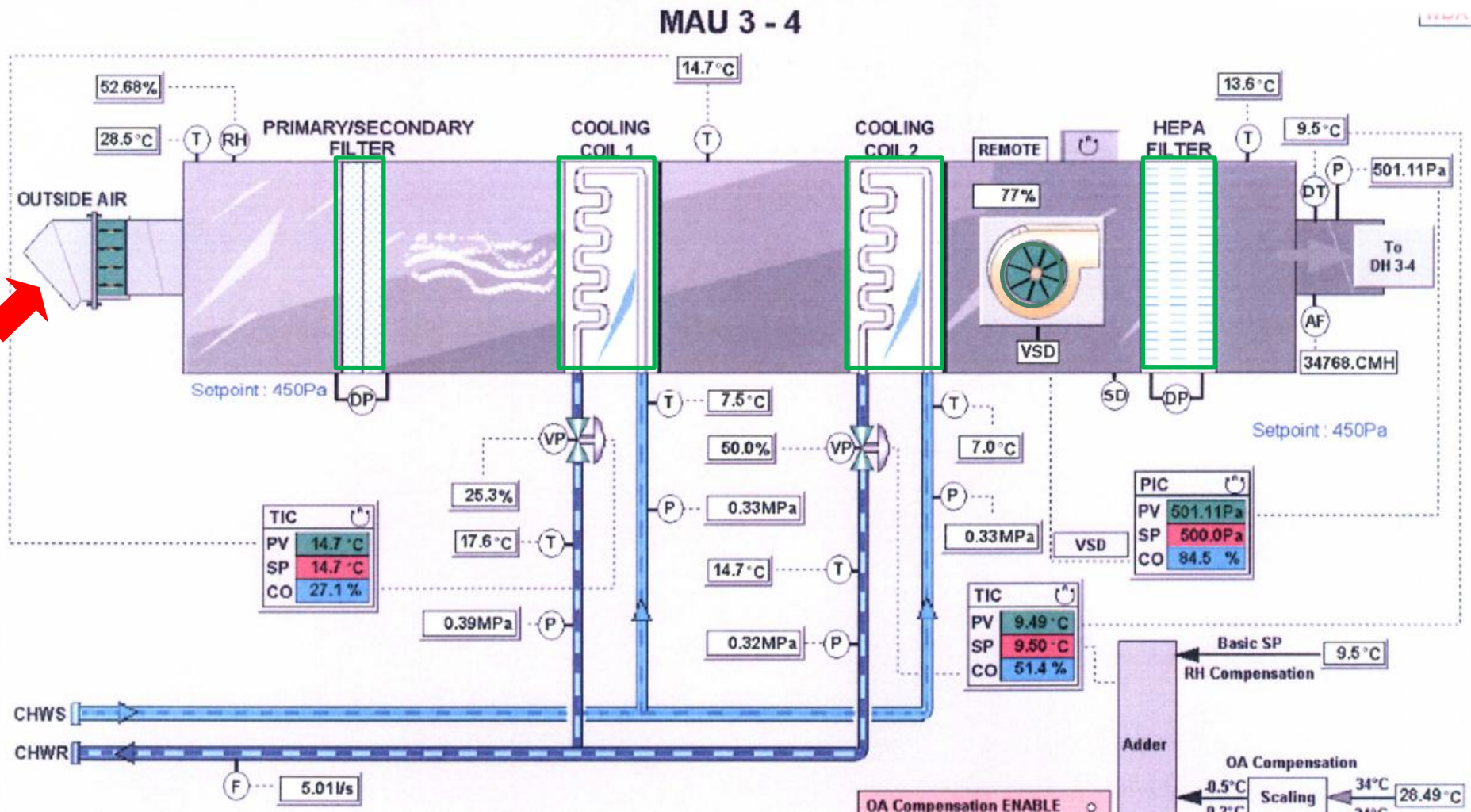
Typical HVAC processes – MAU

Outside-Air Systems



- HVAC systems that use 100% outside air do not use any return air because the return air may contain contaminants.

Typical MAU Layout



Typical HVAC processes – Exhaust fans



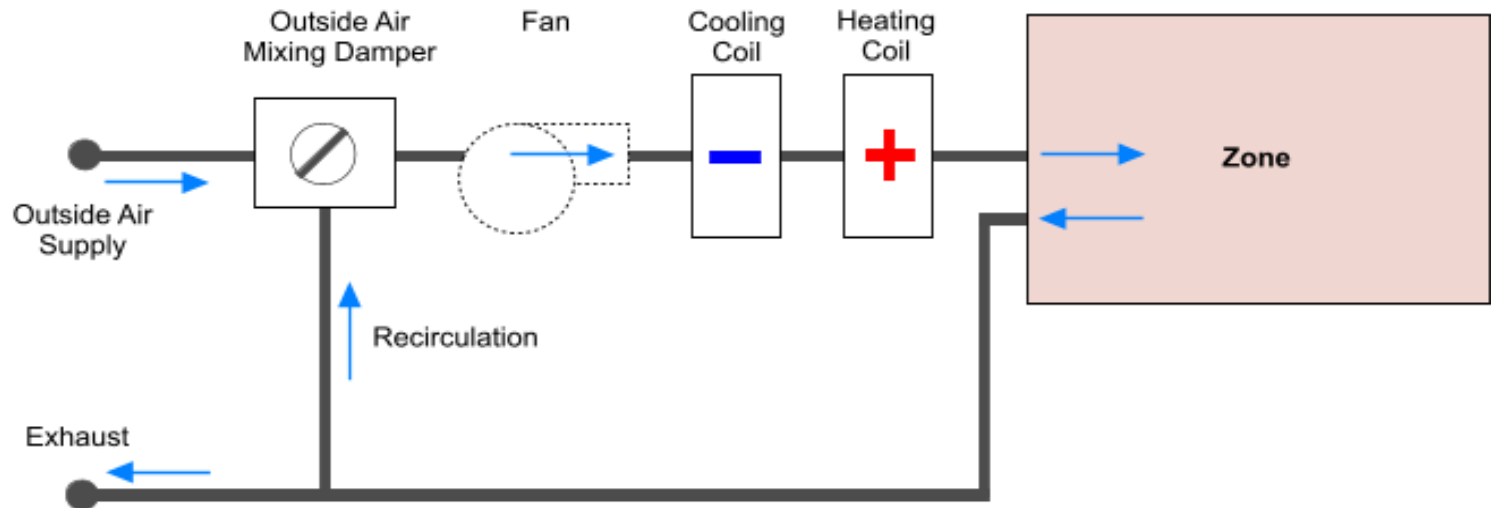
- Used for extracting air from the building to outside the building.
- Application areas are usually toilets, kitchens and other areas where fumes or containments should be extracted out to BIBO or scrubber system.
- Parking areas are usually equipped with exhaust fans that are controlled according to carbon monoxide measurements or time schedules.



Typical HVAC processes – FCU's

- Fan coil units are used to cool smaller areas compare to AHU or MAU.
- Can either circulate the air inside room or function as precooled unit to air-handling unit (AHU).

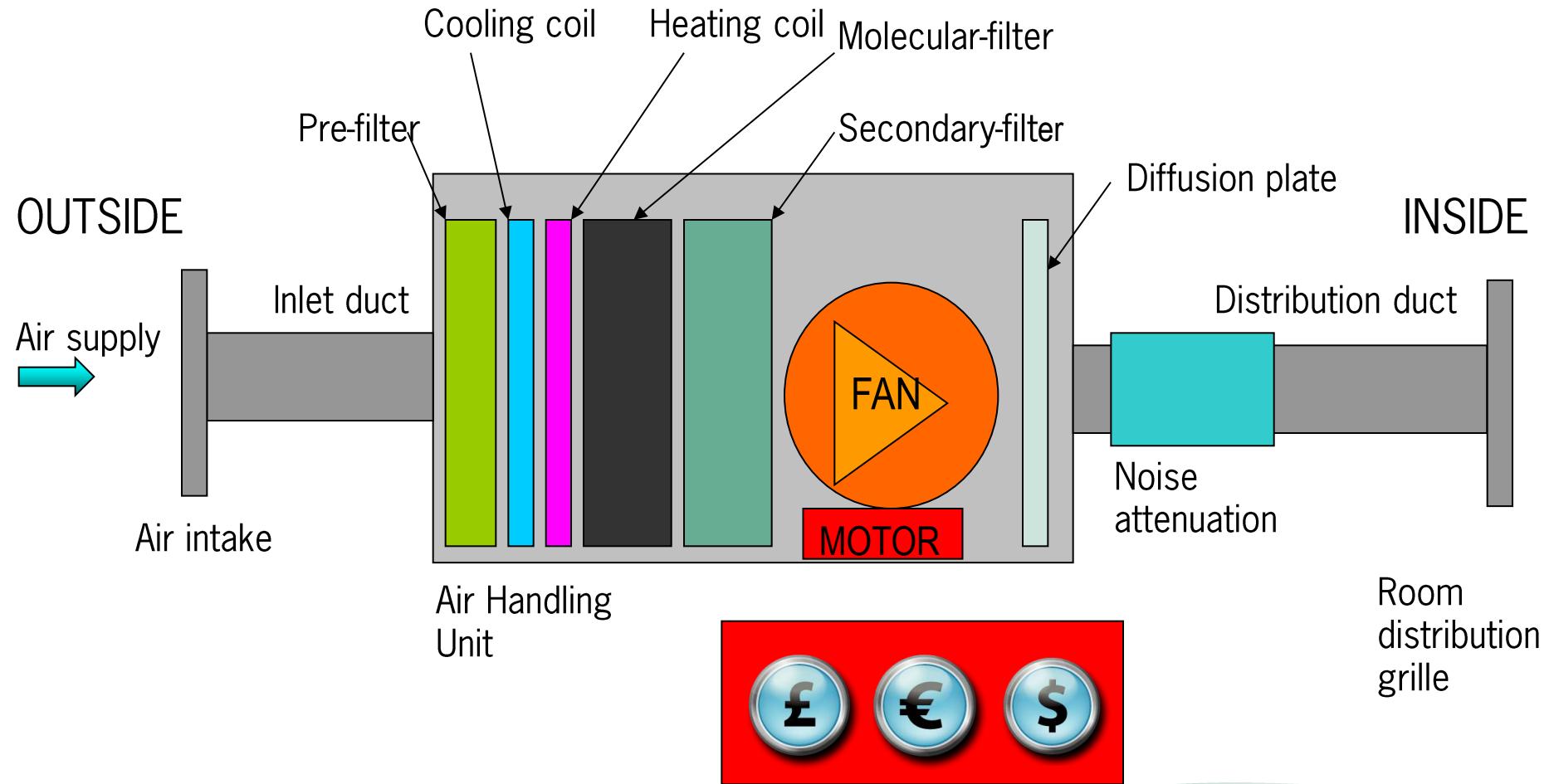
Fan Coil Compact HVAC Airflow Schematic



Notes:

1. The Fan Coil Unit system supplies one zone only.
2. Cooling coil and Heating coil are optional.

The energy cost of ventilation (simplified)



Camfil In Situ (CFIS) Test System



Topics

- 1.Introduction
- 2.Protocols
- 3.Equipment set up
- 4.Report Writing



Introduction



- **Protocols :**
 - **ASHRAE Guideline 26 – 2008** - Guideline for Field Testing of General Ventilation Devices and Systems for Removal Efficiency In-Situ by Particle Size and Resistance to Flow
 - **Eurovent 4/10** - IN SITU DETERMINATION OF FRACTIONAL EFFICIENCY OF GENERAL VENTILATION FILTERS.

(The two protocols are very similar)
- To show how filters performance in “real life” as compared to a test report.

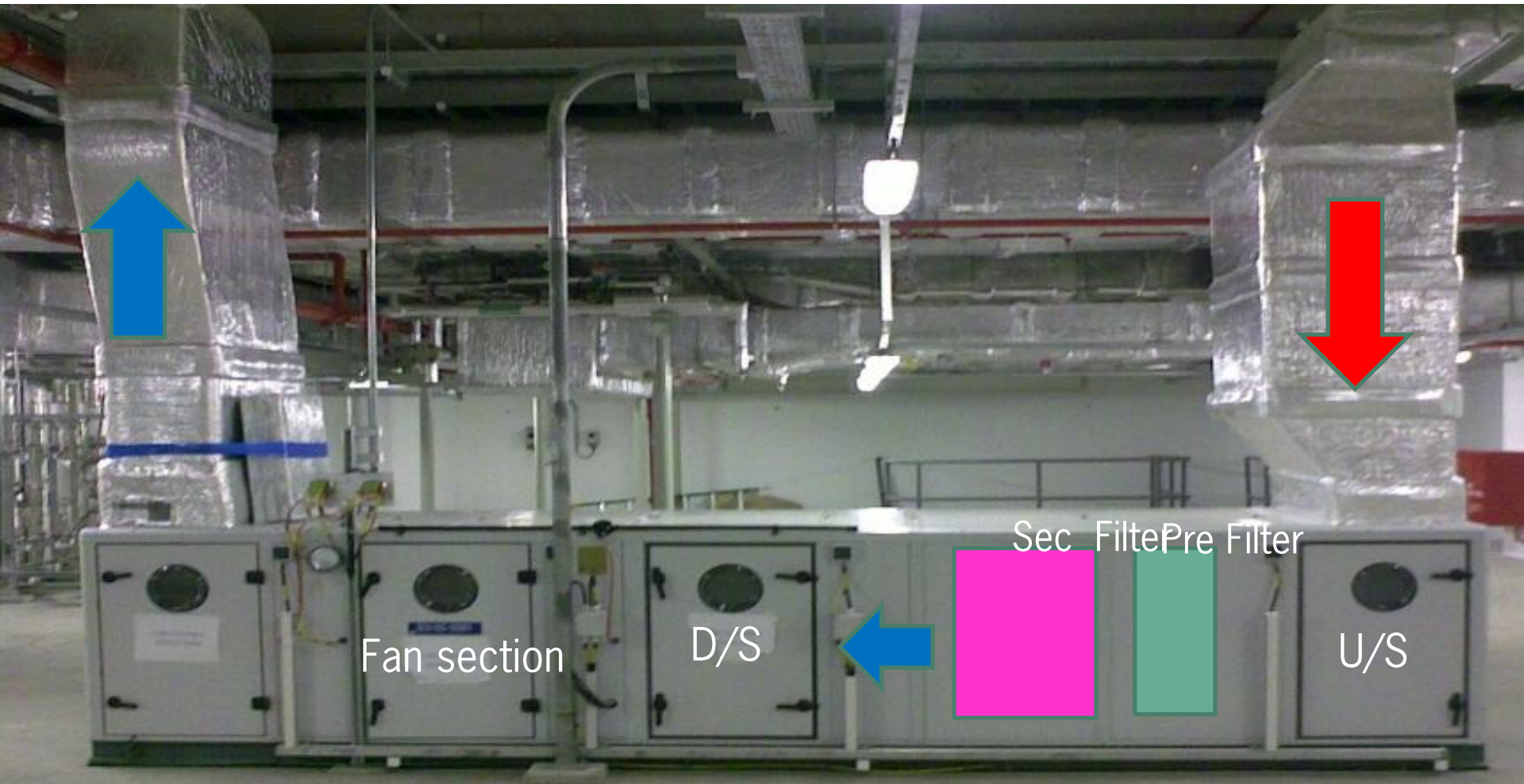
Protocol



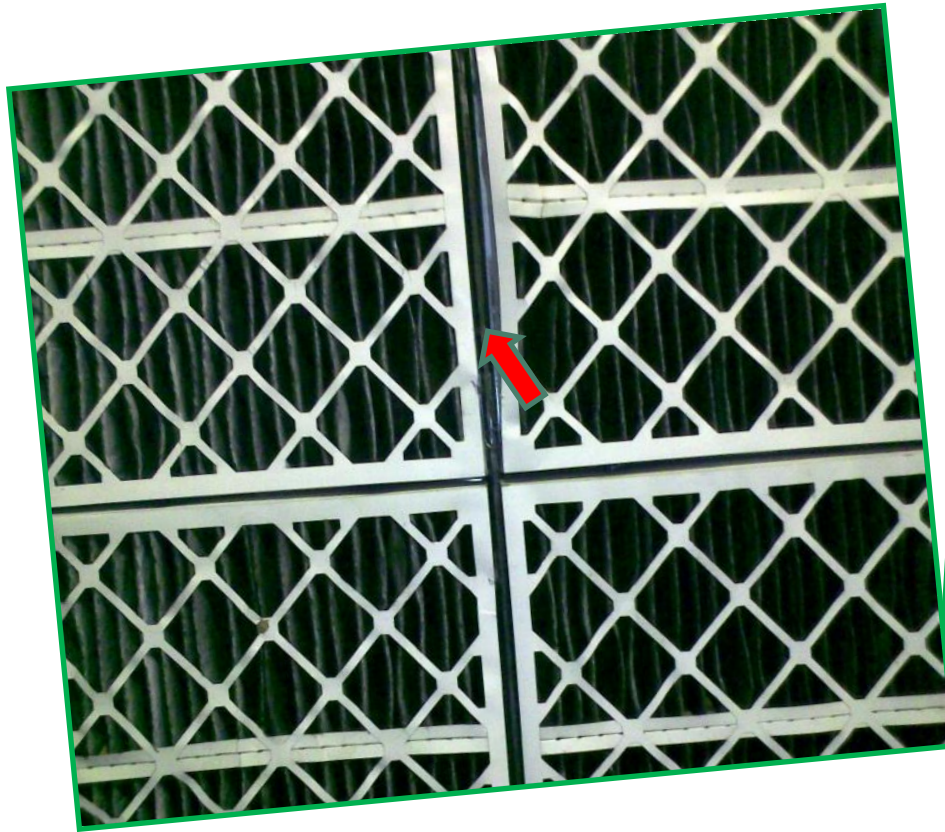
Get approvals complete with forms:

- Approval for testing
- Conduct site inspection
- Filter installation pre testing inspection
- M5 – F9 air filters (only).

Ideal MAU Set up



Example





Filter Installation and pre-testing form

Filter Installation Pretesting Inspection Form

1. Air Handling Unit

	Description	Yes	No	Note
a.	Adequate overall air tightness?			
b.	Doors have adequate seal (very little air leakage)?			
c.	Doors available on both sides of air filter banks?			
d.	Doors have provision for opening/closure from inside AHU?			
e.	Adequate space (up/downstream) of filter banks for probe placement & measurement?			
f.	Adequate space (up/downstream) of other equipment (i.e. coils, fan, etc.) for instrument placement & measurement?			
g.	Sample ports located & labeled (up/downstream) of filter banks?			
h.	Adequate overall interior cleanliness?			
i.	Adequate overall exterior access to AHU?			
j.	Any hazardous conditions (i.e. slip, head knockers, standing water, chemical)?			
k.	Adequate guards provided on the fans & motors?			
l.	Can the airflow through the filters be set to a constant value for the duration of the test?			

2. Local Instrumentation

	Description	Yes	No	Note
a.	Are differential pressure gauges working properly & calibrated?			
b.	Are pressure taps properly aligned? (i.e., not bent, broken, or clogged)			
c.	Is there a velocity gauge working properly and calibrated?			
d.	Is there a temperature gauge working properly & calibrated?			
e.	Is there an RH gauge working properly & calibrated?			

3. Filter/Frames

	Description	Yes	No	Note
a.	Bank #1 - Proper seating/sealing of filters?			
b.	Bank #1 - Clamping hardware in place?			
c.	Bank #1 - Filters free from damage?			
d.	Bank #2 - Proper seating/sealing of filters?			
d.	Bank #2 - Clamping hardware in place?			
e.	Bank #2 - Filters free from damage?			
f.	Bank #3 - Proper seating/sealing of filters?			
g.	Bank #3 - Clamping hardware in place?			
h.	Bank #3 - Filters free from damage?			



Test Application Form

Approval for Testing Form

This approval of the two parties allows for the gathering of filter installation data to provide both parties with an understanding of the actual system performance resulting in acceptable future filtration configuration and performance.

Customer:

Address:

Contractor:

Address:

of Air Handlers:

Environmental Parameters to be measured: (resistance to airflow, air velocity, temperature & RH)

Filter Installation Testing Protocol: Guideline 26

Note: A completed filter installation pre-testing inspection form must accompany this form. (see appendix A)

Comments:

Acceptance (Check one box)

With comments:

Without Comments:

Not accepted:

Customer representative:

Signature

Date:

Contractor representative:

Signature:

Date:

Protocol

- Particle Data - 7 data sets
Upstream - total 3 data sets
Downstream - total 4 data sets
(Min. 6 counts of 20 sec per data sets)
- Airflow measurement
Measure 6 – 12" downstream of filters
Min. 1 data point per filter
- Pressure differential
Min. 1 data point per filter bank



Particle counter

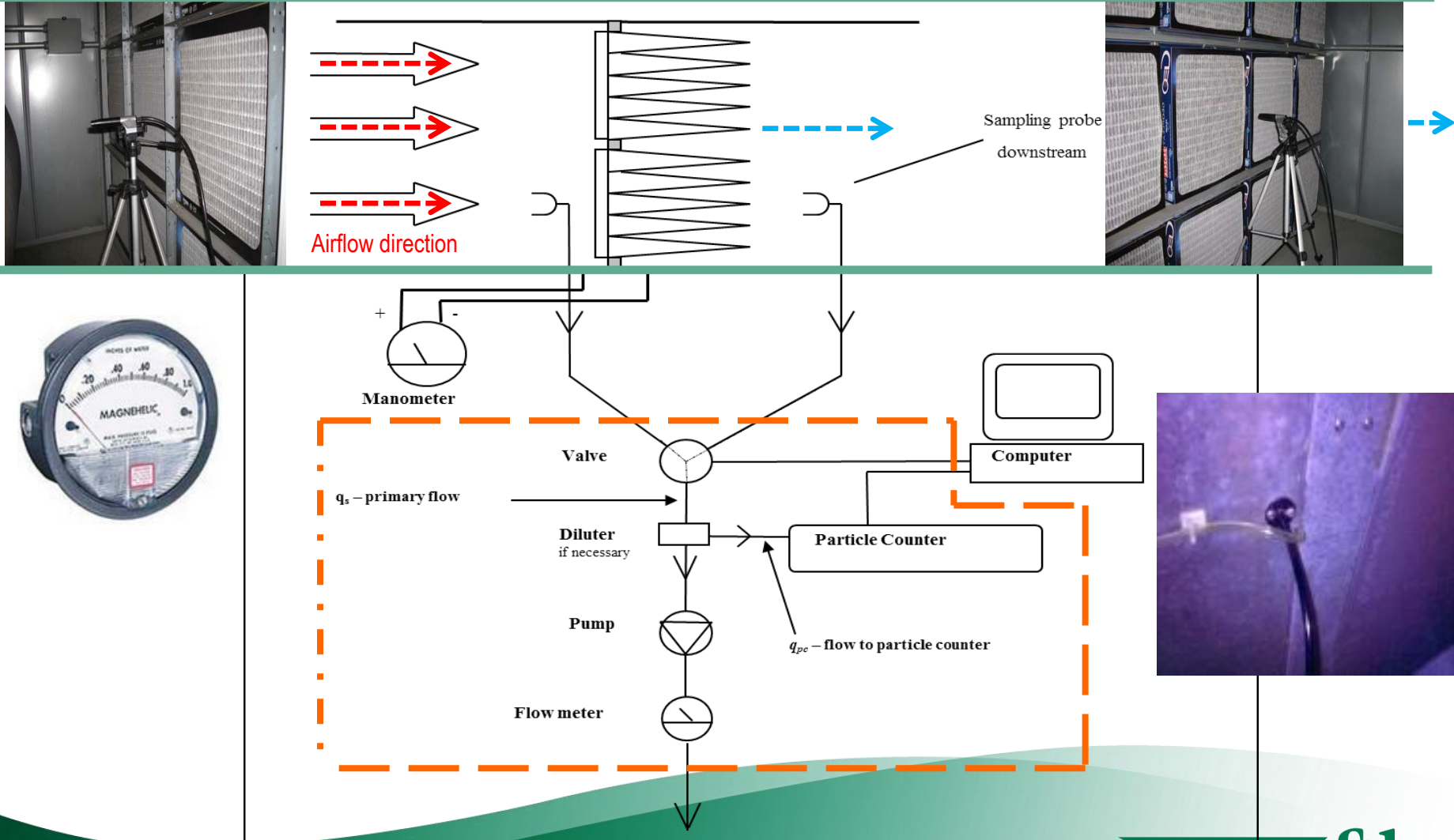


Airflow meter

Equipment set up - Schematic



M5 – F9





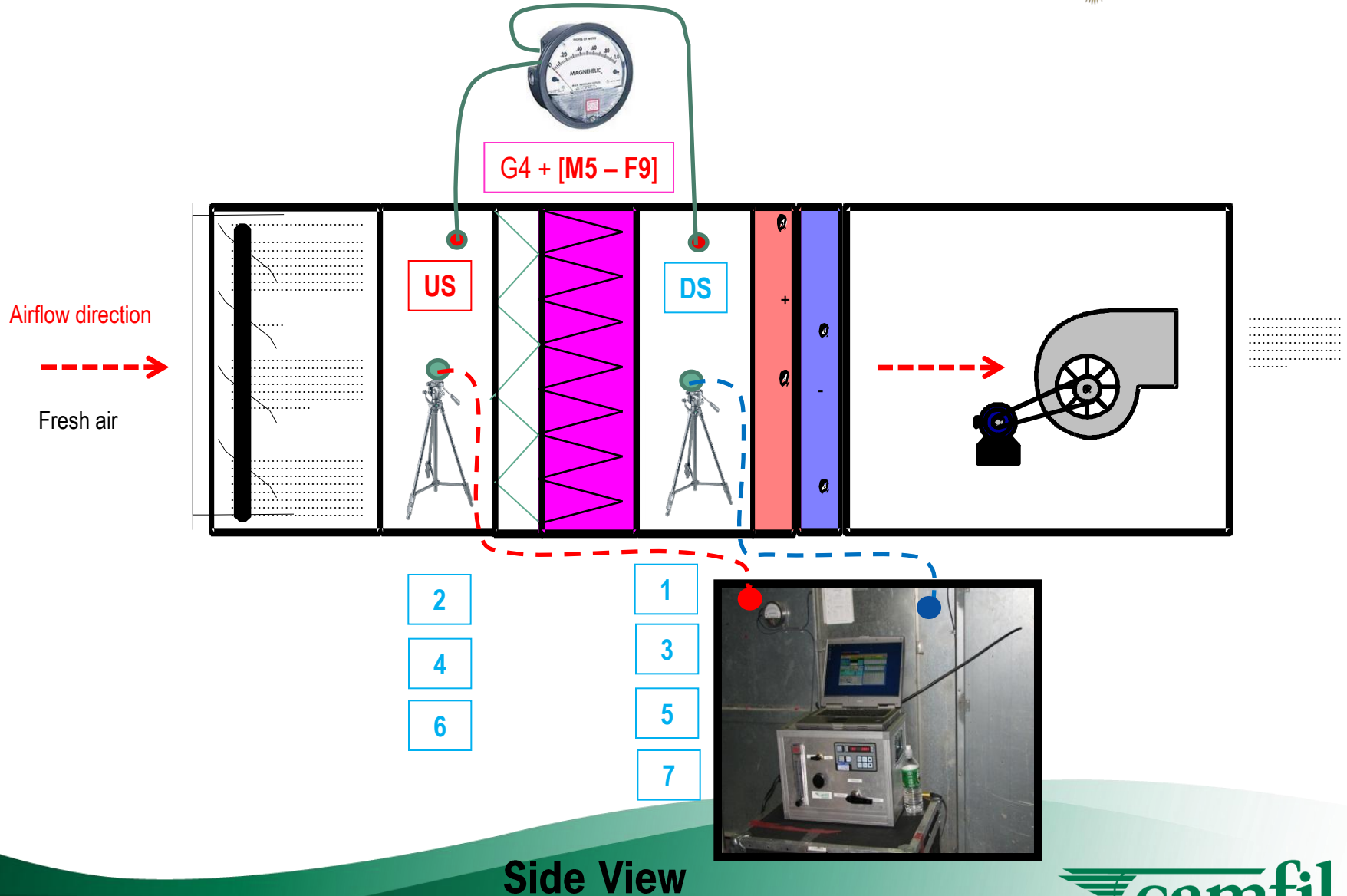
Equipment Set up

- Take air flow measurement, 6 – 12” downstream of the filters.
- Tripod set up - Second filter from entrance by second filter from AHU floor.
- Connect up the tubing from the probes to the particle counter.

Equipment Set up

- Record pressure differential reading from the pressure differential gauge.
- Perform Zero and pre screening check on particle counter.
- Start the sampling.

Equipment set up – Ready !!!





Report Writing

Down-Stream Particle Count Data (Average of 6 counts per data set):

Size Range (µm)	DS1	DS2	DS3	DS4	Average
0.3-0.5	17583	17560	17582	16980	17426
0.5-0.7	936	917	942	876	918
0.7-1.0	81	72	87	77	79
1.0-2.0	30	28	31	30	30
2.0-5.0	7	4	2	4	4
>5.0	0	0	0	0	0
Total	18637	18581	18644	17966	18457

Individual count data attached, Appendix 2.

Up-Stream Particle Count Data (Average of 6 counts per data set):

Size Range (µm)	US1	US2	US3	Average
0.3-0.5	30247	29375	29126	29583
0.5-0.7	1903	1866	1830	1866
0.7-1.0	211	205	202	206
1.0-2.0	97	104	113	105
2.0-5.0	30	32	35	32
>5.0	0	0	0	0
Total	32488	31582	31306	31792

Individual count data attached, Appendix 2.

Filter Efficiency Calculations:

Size Range (µm)	Eff-1, (%)	Eff-2, (%)	Eff-3, (%)	Average Efficiency, (%)	Standard Deviation	95% Upper Confidence Limit, (%)	95% Lower Confidence Limit, (%)	CV, (%)
0.3-0.5	42	40	41	41	0.900	43	39	2.2
0.5-0.7	51	50	50	51	0.600	52	49	1.2
0.7-1.0	64	61	59	61	2.200	67	56	3.5
1.0-2.0	70	72	73	72	1.500	75	68	2.0
2.0-5.0	82	91	91	88	5.400	100	74	6.2
>5.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The efficiency above 5.0um will not be reported due to issues in statistical validation. These values are shown as N/A.

Want a copy of the CFIS Test Guideline then please let us know after the training...

Now time for the real life demo...