ENVIRCO
Innovators in clean air technology

MAC 10 Fan Filter Units

Envirco have been producing innovative and market-leading clean air technologies for more than 100 years

The power behind **your mission**

Johnson Controls

“

Envirco – your trusted innovators in clean air solutions

Pioneers in cleanroom technologies

1960

Envirco builds the world's first commercial unidirectional flow cleanroom at Sandia National Laboratories in New Mexico, US.

1965

Envirco designed, manufactured and installed the first unidirectional flow operating room for the Bataan Hospital in New Mexico, US.

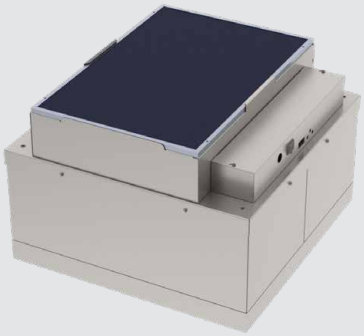
1980

Envirco invented the MAC 10, which was the world's first unidirectional flow fan filter unit (FFU).

Applications

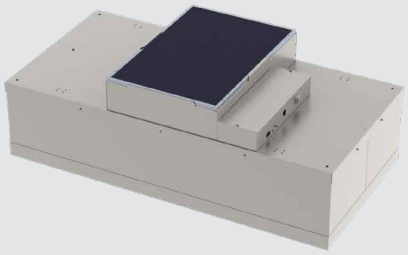
- Semiconductors
- Hospitals
- Pharmaceutical facilities
- Cleanrooms
- Laboratories

Overview



MAC 10 XL

- Unique solution for cleanroom environments
- PSC motor
- Solid-state speed control
- Low-profile design
- Aluminum or stainless steel construction



MAC 10 IQ

- Unique solution for cleanroom environments
- ECM motor
- Solid-state speed control
- Low-profile design
- Aluminum or stainless steel construction

Applications

Envirco representatives have installed fan filter units in cleanrooms and clean areas worldwide for more than 100 years. Many operating rooms and research laboratories, and numerous other facilities have Envirco Fan Filter Units.

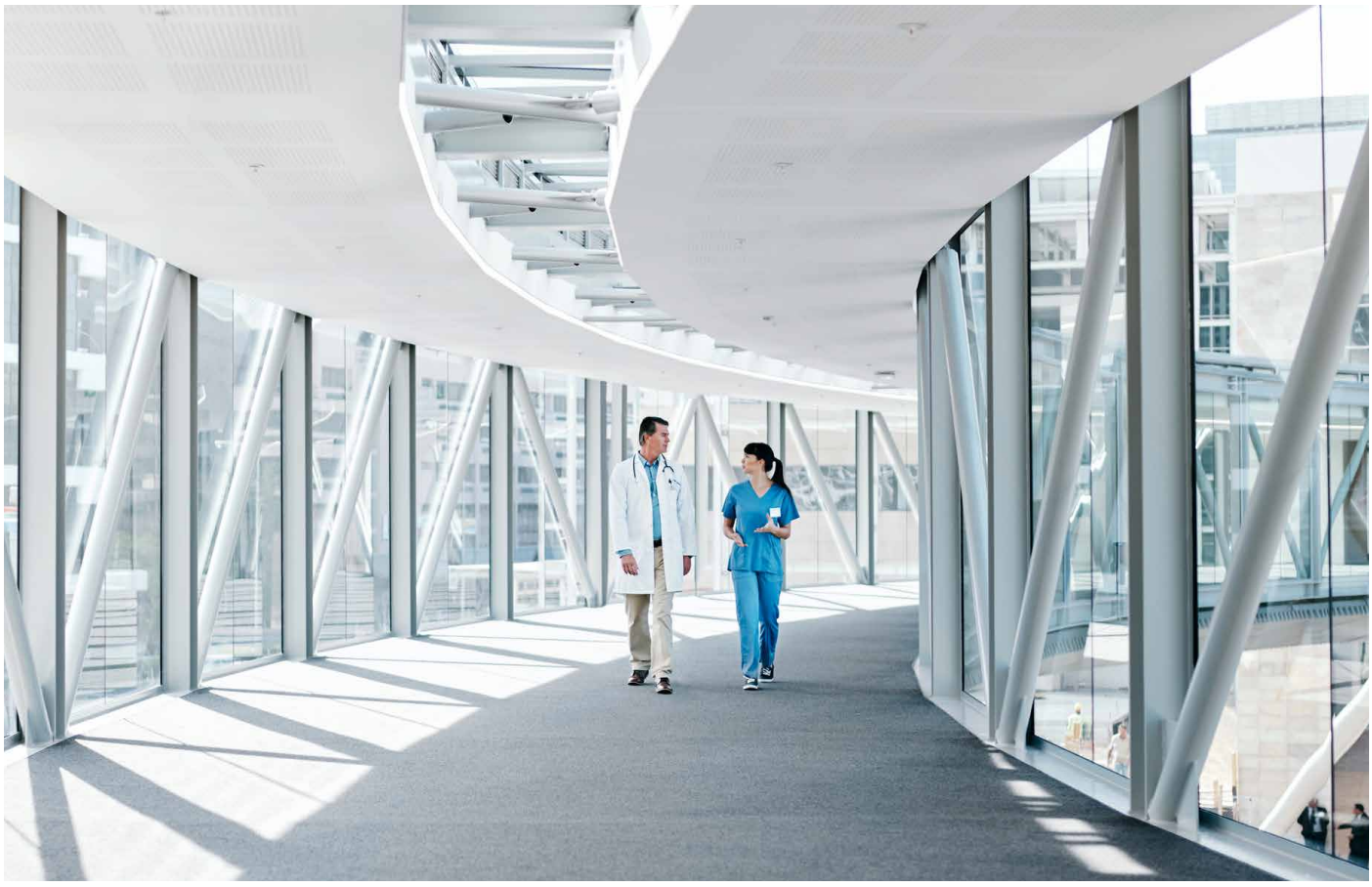
Cleanrooms include hospital operating rooms, electronics manufacturing, pharmaceutical and biotechnology manufacturing, research facilities, automotive painting and many other applications.

General cleanroom information

The design criteria for cleanrooms include cleanliness classification desired, air volume requirements, air motion, proper filtration and removal of contaminants, properly designed equipment and personnel training.

Envirco products are designed to help the engineer with the proper air distribution requirements and air motion. Contamination comes from two sources: external and internal. External sources include incoming air, wall penetrations for pipes, ducts and other HVAC equipment. Internal sources include personnel, process equipment, manufacturing processes and material ingress.

No matter what source has contributed to the unwanted particle count, the design of the cleanroom or clean area facilitates the control of incoming particles and eliminates particles within the environmental envelope.



Applications

Air motion

Air motion is critical to control concentrations of particles in the entire cleanroom or a particular room area. Air motion is either unidirectional, also called laminar, or multi-directional.

Unidirectional air motion is used to push unwanted particles out of the controlled space. Multi-directional air motion can be used to remove unwanted particles by dilution.

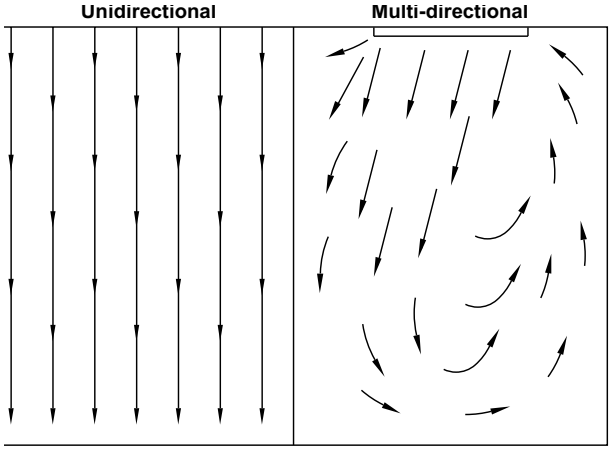
When using multi-directional air motion, the designer depends solely on dilution to achieve the desired cleanliness level. Although dilution may reduce particle levels in the entire room to a moderate, average level, it does not ensure that any given area is controlled to acceptable particulate levels.

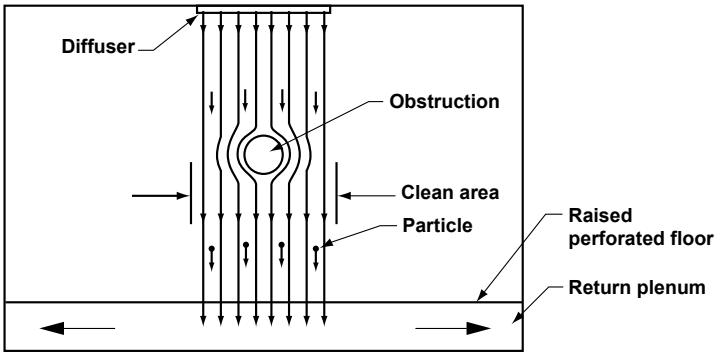
Unidirectional flow can be used to provide clean airflow over an obstruction and push particles to a floor return plenum. As shown in the 'unidirectional flow' figure, return grilles can be located on the room floor and exhausted. In many cases, however, codes require the return air grille to be mounted in the lower side-wall of the room. This allows the floors to be mopped and cleaned for standard conditions. For operating rooms, the return grilles should be mounted with their lower frame at least eight inches above the floor in the far corners of the room.

In many cleanrooms, work areas are designed with unidirectional flow. Fume hoods may obtain supply air from directly inside the room immediately adjacent to the hood while exhausting the air externally. The maximum allowable air velocity in front of fume hoods must be less than the capture velocity of the hood. This room velocity is generally about 15 to 35 fpm, helping to ensure the air within the hood is not induced out of the hood and into the room. Proper location of air devices helps further reduce unwanted air motion. The placement of the diffuser can be critical, and care should be taken to avoid the entrainment of fumes from hoods into the laboratory. Special short-throw diffusers can be used in these locations to eliminate high velocities from moving across the face of the hoods. Typical hood capture velocities are about 100 fpm. Whether unidirectional or multi-directional airflow patterns are utilized, air velocities in the clean area must be controlled. Particles 0.5 micrometers and larger tend to settle on the floor or other work surfaces quickly because of gravity. These particles are easily disturbed and re-entrained into the cleanroom atmosphere, thereby recontaminating a previously clean area. To control re-entrainment, air velocities at the floor area should be below 50 fpm.

Air volume

Air volume is key to creating and sustaining any given class of a cleanroom. Large volumes of clean air are used to dilute contaminated air. In other words, contaminated air is slowly displaced by clean, treated air. As more clean air is brought into the room and contaminated air is removed, the clean air dilutes the contaminated air. This process slowly reduces the particle levels in the room. The job engineer determines volume according to standard industry practices, experience and situational requirements. It is common to specify 10 to 40 air changes per hour in a critical environment. ISO Class 1 to 5 cleanrooms may have air change rates as high as 300 to 600 air changes per hour.





Air filtration and quality control

All cleanrooms utilize filtration systems to purify incoming air and recirculated air. These systems usually include pre-filters that are low cost and easily replaceable. Pre-filters are the first step in extracting or trapping unwanted particles from the air.

Upstream of the high-efficiency particulate (HEPA) or ultralow penetration (ULPA) air filters, pre-filters of 30 percent and then 85 percent significantly reduce the number of contaminants that need to be eliminated by HEPA or ULPA filters. The chart on this page classifies commonly designated filters and their efficiencies.

For cleanroom ISO Classes 6 to 8, several principles should be considered before application regardless of the filter classification specified. The best place for high-efficiency filters is upstream of the air outlets in a remote location. If the high-efficiency filter is an integral part of the air distribution device, removal of the filter should be accomplished from outside the protected zone. Working with the filter in the protected zone creates a high probability of contaminating the clean zone.

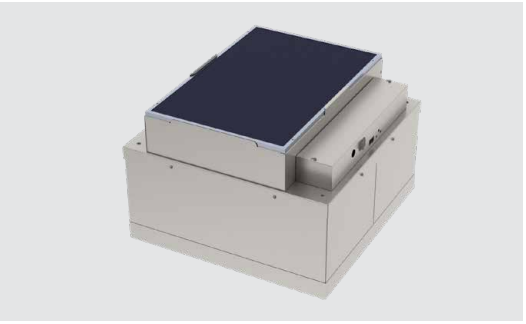
Volume control dampers should be located upstream of the high-efficiency filter so the operation of the damper does not contaminate the airstream.
Air quality includes temperature and humidity control. The industry has developed elaborate systems to control these two factors. Humidity is typically controlled somewhere around 50 percent. Temperature control specifications may be within -17.22°C (1°F) or less.

Pressurization of the cleanroom or clean zone also contributes to air quality. Higher-pressure clean zones help reduce the infiltration of contaminants from outside sources. The typical room differential pressure specified is 0.05 inch WG according to ISO 14644-1. In addition, most critical environmental rooms have positive pressurization to keep contamination out of these areas.

Filter designation and efficiency levels

Name	Designation	Efficiency	Maximum particle sizes
High-efficiency filter	HE	95%	0.3µ
High-efficiency particulate filter	HEPA	99.99%	0.3µ
Ultralow penetration air filter	ULPA	99.9995%	0.12µ

MAC 10 XL



Extra-low watts, sound and profile

The Envirco MAC 10 Fan Filter Unit was the first (FFU) to combine low sound, low watts and a low profile. Measuring only 51 dBA, the MAC 10 XL (2ft x 4ft, 600mm x 1,210mm) provides one of the lowest sound levels of any FFU in the industry. Running at only 310 watts at 90 fpm, the unit uses less energy than traditional FFUs, lowering operating costs. The MAC 10 XL maintains a low profile, measuring less than 13" (330mm). This unit comes standard with the filter integral with the unit housing, requiring the unit to be removed from the ceiling grid to replace the filter.

Standard features

- Low sound, watts, profile and operating costs
- Three-speed switch features 'low', 'medium' and 'high' settings (standard on 2ft x 4ft units)
- Solid-state speed controller standard on 2ft x 2ft and 2ft x 3ft units
- Forward-curved centrifugal fan
- High-efficiency particulate air (HEPA) filter: 99.95 percent at 0.3 µm; UL900 filter: 99.99 percent at 0.12 µm
- Snap-in pre-filter allows for easy replacement and maintenance
- Mill-finished aluminum exterior
- Tested to IEST Recommended Standards
- CE-marked: 230V units

Optional features

- Solid-state speed control: Available on 2ft x 4ft (600mm x 1,210mm) standard units; allows for a full range of settings
- PTFE boron-free ULPA filter
- Monitoring and control system: On-site or remote monitoring and adjustment
- Finish: Powder coating painted or stainless steel
- Custom sizes and configurations available: Perfect for mini-environment applications

Performance data

Unit type	Nominal unit sizes	Motor hp	Max CFM	CFM @ 90 fpm	Watts @ Max CFM	Watts @ 90 fpm	Total unit weight (lbs)	
							AL	SS
MAC 10 XL	2ft x 2ft	1/4	410	315	200	165	41	51
	2ft x 3ft		560	470	270	240	52	62
	2ft x 4ft		660	650	315	310	66	76

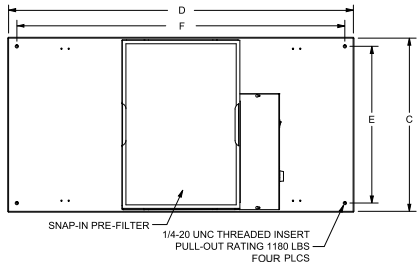
Acoustic performance

Unit type	Nominal unit sizes	Sound level dBA @ 90 fpm	Octave band sound @ 90 fpm					
			2	3	4	5	6	7
MAC 10 XL	2ft x 2ft	48	45	51	49	36	32	25
	2ft x 3ft	41	42	41	44	30	22	14
	2ft x 4ft	51	57	52	49	44	36	30

Performance notes

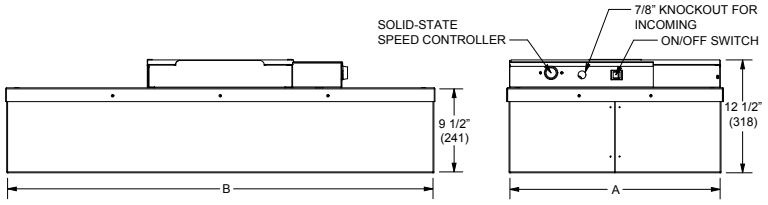
- Performance tested in accordance with the ANSI/AMCA 210-07 and ANSI/ASHRAE 51-07 test standards for Certified Aerodynamic Performance Rating
- Max CFM rating based on free air volumes at high-speed motor setting
- 90 fpm values based on the active-filter face area
- Heat gain: BTU = watts x 3.413

Top view



Nominal unit sizes	A	B	C	D	E	F
	In (mm)	In (mm)	In (mm)	In (mm)	In (mm)	In (mm)
2ft x 2ft	23 5/8 (600)	23 5/8 (600)	23 7/8 (606)	23 7/8 (606)	21 3/8 (543)	21 3/8 (543)
2ft x 3ft	23 5/8 (600)	35 5/8 (905)	23 7/8 (606)	35 7/8 (911)	21 3/8 (543)	33 3/8 (848)
2ft x 4ft	23 5/8 (600)	47 5/8 (1,210)	23 7/8 (606)	47 7/8 (1,216)	21 3/8 (543)	45 3/8 (1,152)

Side view



Panel sizes	OA face dimensions
24" x 24"	23.63" x 23.63" (600 x 600 mm)
48" x 24"	47.63" x 23.63" (1,210 x 600 mm)

MAC 10 XL

The MAC 10 XL (2ft x 4ft) is available with the three-speed switch or speed control (2ft x 2ft and 2ft x 3ft units come with speed control as standard). Custom sizes are available. Consult the factory for both size and control options.

Full-load amps

PSC	115V	2.70
	208V	1.30
	277V	1.20

Active-filter face areas

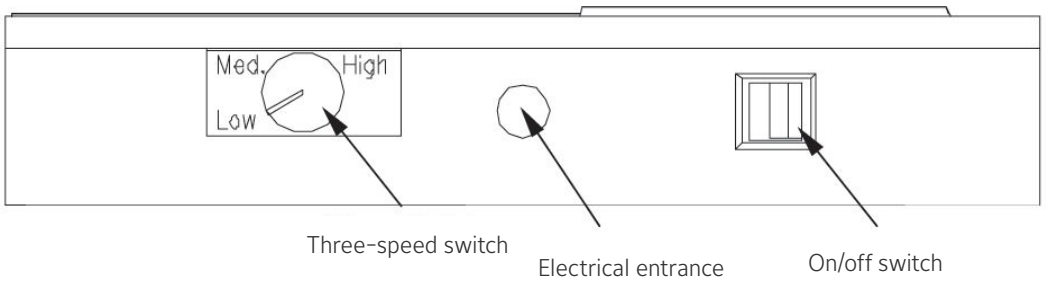
Unit type	Nominal sizes	Active-filter face areas
MAC 10 XL	2ft x 2ft	3.5
	2ft x 3ft	5.3
	2ft x 4ft	7.2

MAC 10 XL controls

On/off switch - speed/airflow adjustment

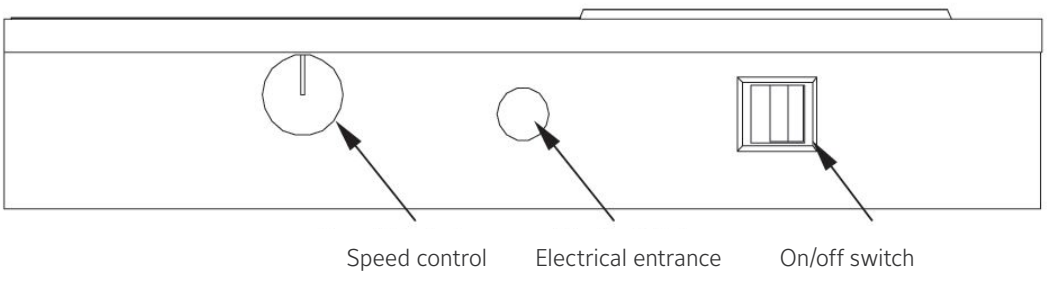
All units are equipped with speed control, enabling airflow adjustment at any setting within the recommended performance range. The speed control knob is located on the side of the electrical box, adjacent to the on/off switch. For units equipped with a three-position rotary switch, it is located on the side of the electrical box (See figure below).

The recommended fan speed during initial start-up and operation is the 'low' speed. As airflow eventually decreases due to filter loading, fan speed may be increased by moving the rocker switch to the top 'medium' position and finally to the 'high' position. Periodic airflow velocity readings (per IEST Reccommended Practices) should be conducted to determine the filter condition and appropriate fan speed setting.



Optional speed control

Units furnished with the optional speed control (standard with 2ft x 2ft and 2ft x 3ft units) enable airflow adjustment at any setting within the recommended performance range. The speed control knob is located on the side of the electrical box, adjacent to the on/off switch.



Motor speed control

The Envirco Control Card is equipped with a motor speed controller. The microprocessor-based unit provides a wide range of variable voltage speed control for PSC and shaded-pole motors. Additionally, the electronic speed control of PSC-AC motors is an economical alternative to expensive BLDC motors.

Features

- Variable voltage phase control
- Up to three amp load capability
- Three-wire option reduces motor hum and increases efficiency at lower speeds
- RS485 network connectivity (MODBUS protocol):
  - Twisted pair cable
  - RJ45 connector
- Monitoring input for pressure switch or similar sensors
- Minimum speed setpoint (register set)
- Soft-start reduces motor start current
- LED indicates board status

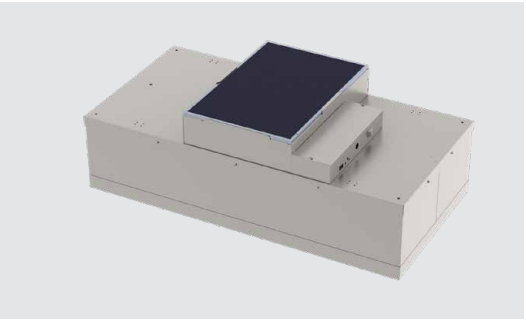
Standalone or networked fan/blower phase control card

The standalone or networked fan/blower phase control card is designed for use with a single-phase permanent split capacitor (PSC) or shaded-pole induction motors. Capable of 3.0 or 4.0 ampere in 230-volt models, these controls now have three-wire or two-wire connection options. Open-loop or closed-loop are selectable in these controllers. The standalone or networked fan/blower phase control card has network connectivity (MODBUS-based) through RJ45. PLC implementation will interface with major network protocols (LonWorks, BACnet, PROFIBUS, etc.).

Features

- Three-wire or two-wire control available
- Suitable for 50Hz or 60Hz
- 'Speed set memory' resets to the last setting under power loss
- Open-loop analog control input (0-5vdc, 4-20mA)
- Closed-loop control option (external hall sensor feedback):
  - PID values programmable via network
  - Measures and controls the actual speed
- Open-frame (UL-approved cover optional)
- Diagnostic LEDs:
  - Status/fault
  - Network traffic
- Overload: 125 percent for 30 seconds

MAC 10 IQ



The first fan filter unit (FFU) with a built-in brain

The MAC 10 IQ is the world's first smart fan filter unit. With its microcomputer-controlled DC motor, the MAC 10 IQ dynamically adjusts itself to maintain the set airflow, compensating for changes in static pressure, filter loading or other local conditions.

Competitively priced, the MAC 10 IQ offers low sound, low energy consumption and a low profile with high performance and built-in intelligence control. MAC 10 FFUs are used worldwide for a variety of critical clean air applications.

The novel MAC 10 IQ FFU uses a combination of DC motor technology with Envirco's patented baffling system and forward curve fan to make it intelligent and energy-efficient. This unique combination takes advantage of Envirco's expertise in FFUs and the energy efficiency of DC motors.

The EC motor has an internal microcomputer that provides low energy consumption (105 watts at 0.45m/s), high performance and longer motor life. The IQ utilizes Envirco's patented VE5 baffling technology, offering low sound levels that are a MAC 10 family benchmark.

Features

- EC brushless DC motor with internal microprocessor. Universal Control Card allows manual control via the integral potentiometer. Remote speed control via 0-10V analog signal. Network control via MODBUS compatible RTU network protocol
- Low power consumption FFU at 105 watts
- Low sound at only 51 dBA
- High-efficiency particulate air (HEPA) filter: 99.99 percent at 0.3 micron (H13).
- 150 Pa of external static capability at 0.45m/s.
- Forward-inclined centrifugal-type fan
- Walkable plenum (excluding pre-filter)
- Snap-in pre-filter allows for easy replacement and maintenance (406mm x 591mm x 13mm)
- CE-marked: 230V units
- Mill-finished aluminum

Performance data

Unit type	Nominal unit sizes	Motor hp	Max CFM	CFM @ 90 fpm	Watts @ max CFM	Watts @ 90 fpm	Total unit weight (lbs)	
							AL	SS
MAC 10 IQ	2ft x 2ft	1/3	410	315	145	85	41	51
	2ft x 3ft		560	470	200	140	52	62
	2ft x 4ft		660	650	260	235	66	76

Acoustic Performance

Unit type	Nominal unit sizes	Sound level dBA @ 90 fpm	Octave band sound @ 90 fpm					
			2	3	4	5	6	7
MAC 10 IQ	2ft x 2ft	46	48	48	49	44	38	30
	2ft x 3ft	47	40	42	42	33	25	16
	2ft x 4ft	48	46	50	47	40	38	35

Performance notes:

- Performance tested in accordance with the ANSI/AMCA 210-07 and ANSI/ASHRAE 51-07 test standards for Certified Aerodynamic Performance Rating
- Max CFM rating based on free air volumes at high-speed motor setting
- 90 fpm values based on the active-filter face area
- Heat gain: BTU = watts x 3.413

Constant airflow

Unlike conventional induction motors, the EC motor regulates itself by automatically adjusting its torque and speed. In addition, each MAC 10 IQ includes a visual control unit that provides a constant airflow of 0.26–0.66m/s over a wide range of static pressure.

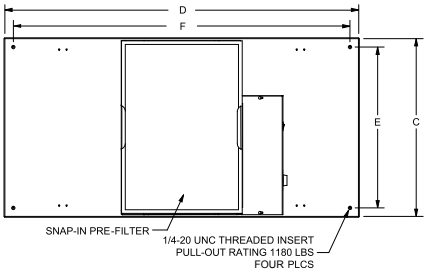
The MAC 10 IQ maintains airflow so constantly and consistently that the need for future balancing is greatly reduced. The correlated velocity feature of the visual control unit provides infinite control and fine-tuning capabilities for each FFU.

The MAC 10 IQ efficiently and easily maintains set cleanroom airflow velocities that meet IEST Recommended Practices. With its unique constant airflow feature, the MAC 10 IQ is also an ideal component for mini-environments.

Options

- Controls: A range of console and PLC options are available for standalone or integrated BMS network control
- Ultralow penetration air filter (ULPA): 99.9995 percent at 0.12 micron (U15)
- Custom sizes and configurations: Perfect for mini-environment applications
- Finish: Powder coating painted or stainless steel

Top view



Nominal unit size	A	B	C	D	E	F
	In (mm)	In (mm)	In (mm)	In (mm)	In (mm)	In (mm)
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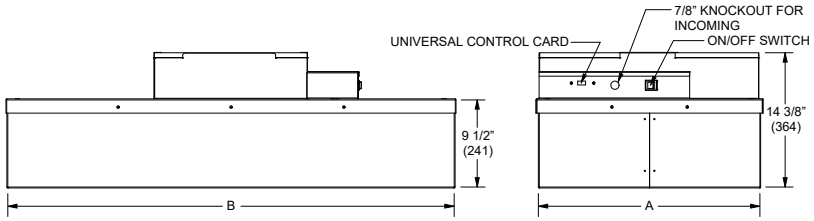
Side view



Panel sizes	OA face dimensions
24" x 24"	23.63" x 23.63" (600 x 600 mm)
48" x 24"	47.63" x 23.63" (1,210 x 600 mm)

Full-load amps

ECM	115V	4.50
	208V	2.80
	277V	2.30

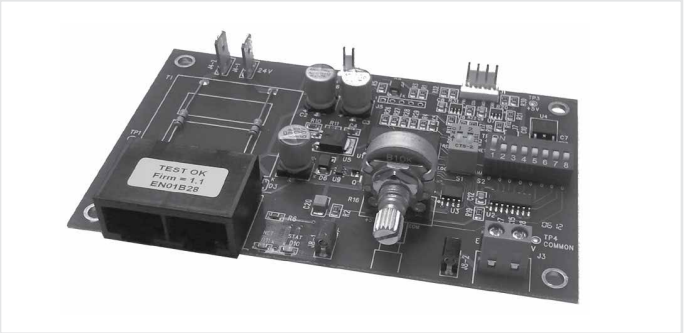
Active-filter face areas

Unit type	Nominal sizes	Active-filter face areas
MAC10 IQ	2ft x 2ft	3.5
	2ft x 3ft	5.3
	2ft x 4ft	7.2

MAC 10 IQ controls

Universal Control Card (CON4)

Envirco's ENV1028 Universal Control Card provides MODBUS network and analog control capabilities to an Envirco Fan Filter Unit equipped with an electrically commutated motor. Three different control modes provide installation versatility by allowing the FFU to be controlled via a MODBUS RTU network, analog 0-10 VDC control signal, or adjusting the onboard potentiometer. In addition, the ENV1028 Universal Control Card is fully compatible with all Envirco's plug-and-play system control consoles using MODBUS RTU.



Features

- Networkable via MODBUS RTU
- 0-10 VDC analog control
- Manual control via onboard potentiometer
- RJ45 for networking connection
- Screw terminals for analog control
- Test probe jacks for DC mV signal output of RPM and motor control setpoint
- Support for external LED (10mA) remote status notification via 2-pin MTA connector
- Onboard green LED for board status notification
- Onboard red LED for network traffic
- Powered from the network or local supply

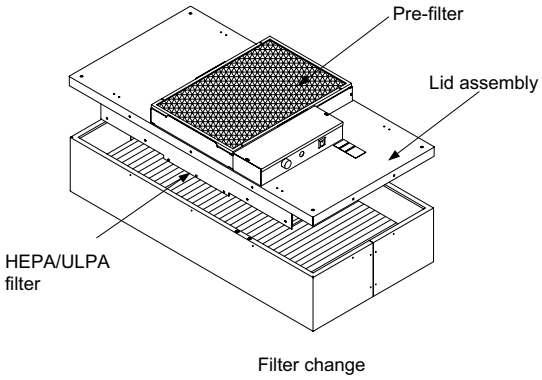
Visual Control Unit (VCU)

The visual control unit (VCU) allows accurate manual adjustment and fan monitoring using an ECM motor. These are fractional horsepower air-moving motors featuring an internal microprocessor. The design provides exceptional efficiency, performance and motor life. In addition, these self-regulating motors may be factory-configured so the fan will provide constant mass airflow.

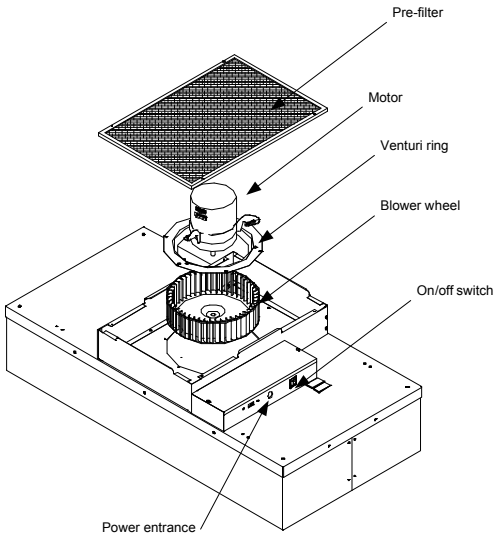
The visual control unit features a four-digit LED numerical display for easy reading in dark spaces. Watch the display and set the flow index with a screwdriver. Twenty seconds later, the display shows the motor RPM. Then, the display periodically alternates between the flow index and motor RPM. The visual control unit may also be used where automation systems only turn the fan on or off.

Options and accessories

Filter change

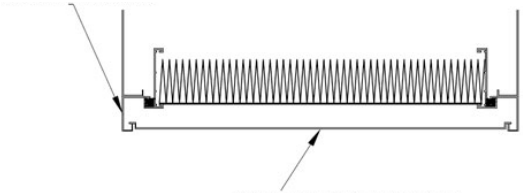


Motor/electrical removal



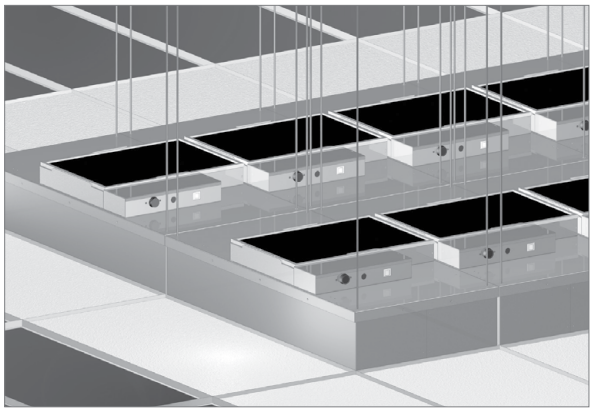
Filter and gel seal details

Lower housing is welded with full penetration welds to provide a leak-free mate to the gel seal filter. No caulk is required.



The diffuser screen has an interference fit with the housing. No hardware is required.

Array view



Basic cleanroom terminology

Clean space
This is a defined area where particle concentration and environmental conditions are controlled at or below specified limits (ASHRAE 2011 Handbook).

Cleanliness classification (class)
Cleanliness classification (class) is determined by allowable particle concentrations per cubic meter over a range of particle sizes as outlined in ISO standard 14644-1 (see chart below). For example, an ISO Class 5 cleanroom is defined as a space where the particle concentration does not exceed 100,000 particles per cubic meter for 0.1µm particles or 832 particles per cubic meter for 1µm particles.

Cleanroom
A cleanroom is an enclosed area constructed explicitly to control airborne particulates, temperature, humidity, air pressure, airflow patterns, air motion, vibration, noise, viable organisms and lighting (ASHRAE 2011 Handbook).

First air
Air is supplied directly from the HEPA filter before it passes over any work location (ASHRAE 2011 Applications Handbook).

High-efficiency filter (HEPA)
The high-efficiency filter (HEPA) has more than 99.97 percent efficency at 0.3 micrometer (ASHRAE 2011 Applications Handbook).

Make-up air
This is air introduced to the secondary (recirculated) air system for ventilation, pressurization and replacement of exhaust air.

Particle concentration
The particle concentration is the number of individual particles per unit volume of air (ASHRAE 2011 Applications Handbook).

Particle size
The particle size is the apparent maximum linear dimension of a particle in the plane of observation (ASHRAE 2011 Handbook).

Secondary air
Secondary air is the air that recirculates through the workspace (ASHRAE 2011 Applications Handbook).

Ultralow-penetration air filter (ULPA)
The ultralow-penetration air filter (ULPA) has a minimum efficiency of 99.999 percent with 0.12-micrometer particles (ASHRAE 2011 Applications Handbook).

Unidirectional flow
Unidirectional flow was formerly called laminar flow. This occurs when air flows at constant and uniform velocity in the same direction (ASHRAE 2011 Handbook).

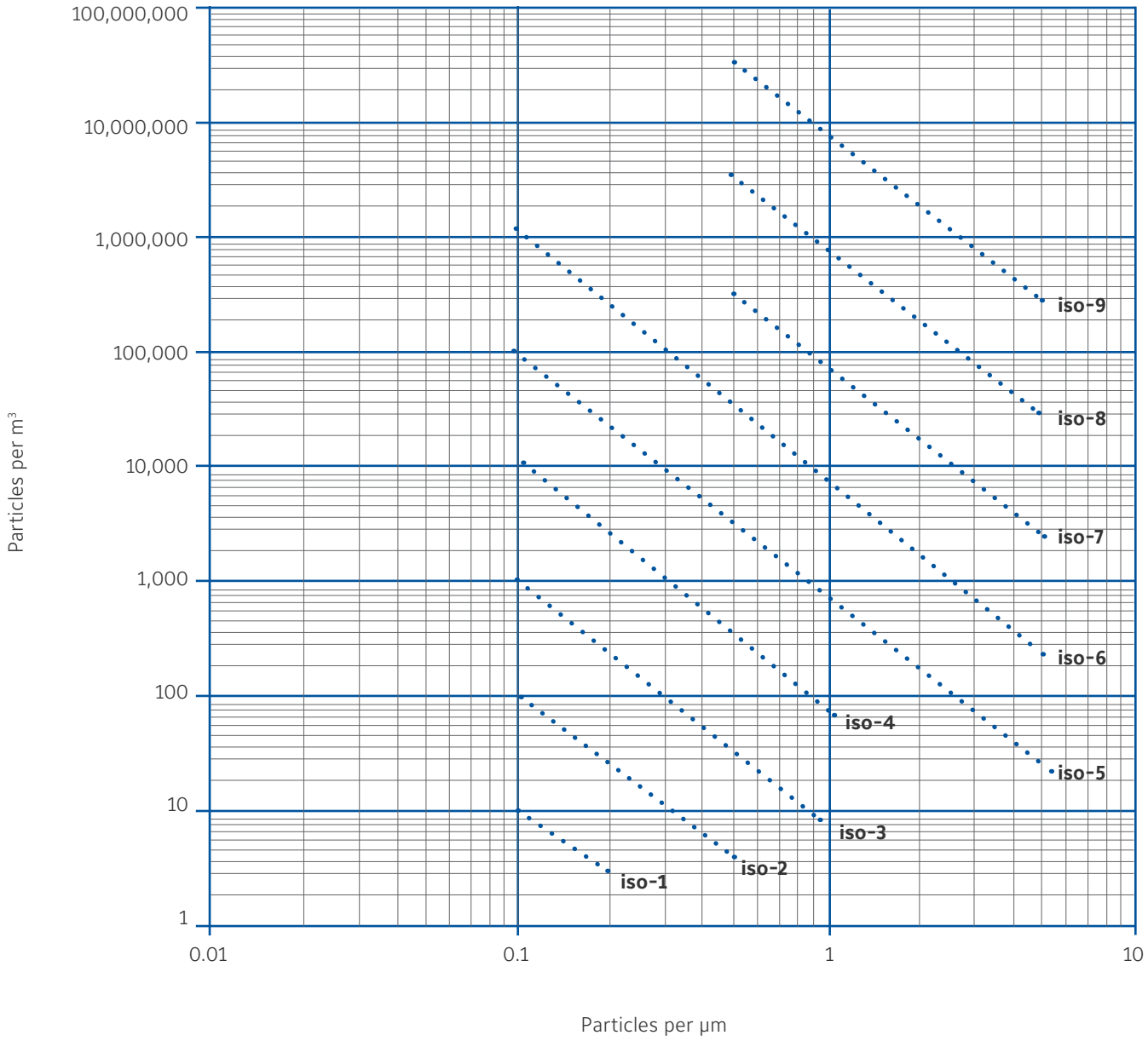
Workstation
The workstation is an open or enclosed work surface with a direct air supply (ASHRAE 2011 Handbook).

Airborne particle concentration limits from ISO Standard 14644-1

ISO 14644 Class	0.1 µm	0.2 µm	0.3 µm	0.5 µm	1.0 µm	5.0 µm
	Particles per m^3					
1	10	2				
2	100	24	10	4		
3	1000	237	102	35	8	
4	10,000	2370	1020	352	83	
5	100,000	23,700	10,200	3520	832	29
6	1,000,000	237,000	102,000	35,200	8320	293
7				352,000	83,200	2930
8				3,520,000	832,000	29,300
9				35,200,000	8,320,000	293,000

Note: Values shown are the concentration limits for particles equal to and larger than the sizes shown.
$C_n=10^N(0.1/D)^{2.08}$ where C_n=concentration limits in particles/m^3, N=ISO class, and D=particle diameter in µm

Air Cleanliness Class Limits
U.S. Federal Standard 209



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