Cleanroom Purification Engineering

1. Working Process

The cleanroom employs a full-process closed-loop pollution control technology, integrating air purification, environmental regulation, personnel and material control, and dynamic monitoring across all aspects. It establishes a comprehensive cleanliness protection system with no blind spots, thoroughly blocking the intrusion of particles, harmful gases, and external contamination. It is suitable for various high-cleanliness production and experimental scenarios, with five core modules as follows:

1. Multi-Stage Progressive Air Filtration: Adopts a three-stage filtration system combining pre-filter + medium-efficiency filter + HEPA/ULPA. Each layer intercepts air pollutants. The pre-filter blocks large particles, dust, and coarse impurities. The medium-efficiency filter captures medium-sized particles. The terminal HEPA/ULPA filter precisely captures particles as small as 0.3 μm and below, with filtration efficiency reaching 99.97%-99.995%, thoroughly blocking fine particle intrusion. Additionally, activated carbon modules are paired to efficiently adsorb harmful gases such as formaldehyde and odors, achieving deep air purification while controlling both particulate and gaseous pollution.

2. Graded Customized Airflow Organization: Airflow patterns are customized according to cleanliness levels to prevent pollutant retention. High-cleanliness areas such as Class 100 adopt vertical unidirectional airflow design with uniform and stable airflow that quickly removes area pollutants, ensuring extreme cleanliness. Class 1000 and below areas adopt non-unidirectional airflow design, reasonably distributing airflow to balance purification efficiency and energy consumption, with directional exhaust to prevent dirty air accumulation and eliminate purification blind spots.

3. Temperature and Humidity with Pressure Differential Automatic Control: Relies on constant temperature and humidity purification air conditioning, linked with high-precision sensors for real-time temperature and humidity regulation, stably meeting process standards. Simultaneously adopts gradient positive pressure protection to maintain reasonable pressure differentials between clean and non-clean areas, and between

different cleanliness levels, strictly preventing external unpurified air backflow, eliminating cross-contamination from the airflow path, and ensuring clean area environmental independence and stability.

4. Personnel and Material Purification Control: Strictly controls personnel and material entry and exit to cut off external contamination paths. Personnel must undergo更衣 (changing), air shower, and standardized disinfection procedures to remove surface contaminants before entry. Materials are transferred through double-layer interlocked pass-through windows to avoid contact with non-clean air. The overall enclosure structure uses anti-static, easy-to-clean materials to reduce dust and bacteria adhesion, facilitating daily disinfection and maintenance, and reducing internal contamination risks.

5. Intelligent Dynamic Monitoring and Operation & Maintenance: Equipped with intelligent online monitoring system, real-time 24-hour monitoring of core indicators such as cleanliness, temperature, humidity, pressure differential, and particle count, with automatic warnings for anomalies and rapid response and handling. Equipped with standardized operation and maintenance procedures including regular cleaning, filter replacement, and system calibration, forming a closed-loop management of monitoring-warning-handling-maintenance to ensure long-term stable and compliant operation of the cleanroom.



2. Core Parameters

1. Cleanliness Class (Core Classification)

Cleanliness Class	≥0.5 μm Particle Count (个/m³)	Application Scenarios
Class 100	≤3520	Ultra-precision chip manufacturing, sterile pharmaceutical, high-precision scientific research
Class 1000	≤35200	Precision machining, high-end medical device assembly
Class 10000	≤352000	General pharmaceutical workshop, sterile laboratory
Class 100000	≤3520000	Food processing, electronic component production
Class 1000000	≤35200000	General precision packaging, low-requirement clean operations

2. Other Controllable Core Parameters

Temperature: Standard control range 20-26 ° C, accuracy up to ± 0.5 ° C, electronics workshop preferred 22 ± 2 ° C, pharmaceutical industry suitable 20-25 ° C

Humidity: 45%-65%RH, fluctuation ≤ ± 3%-5%RH, to prevent static electricity and mold growth

Pressure Differential: Clean area vs non-clean area ≥10Pa, adjacent different-class clean areas ≥5Pa, maintain positive pressure protection

Airflow Velocity: Unidirectional flow area 0.2-0.5m/s, non-unidirectional flow area adjusted as needed, ensure airflow uniformity

Static Control: Floor and enclosure structure use anti-static materials, static voltage controlled within safe range. Noise and Lighting: Noise ≤60dB, lighting brightness customized as needed, meeting production operation and inspection requirements

3. User Guide

1. Pre-Use Preparation: After cleanroom installation and debugging is complete, system acceptance and cleanliness testing must be conducted before use. Before use, remove all clutter from the room, thoroughly clean and disinfect floors, walls, and equipment, and close doors and windows to maintain a sealed state.

2. Personnel Entry and Exit Regulations: Strictly implement personnel purification procedures, change into dedicated cleanroom garments and shoe covers, wear masks and gloves, and pass through the air shower for dust removal before entry. Prohibit carrying cosmetics, snacks, non-clean items, etc. Strictly prohibit arbitrarily opening or closing doors and windows, or wandering between work areas.

3. Material and Equipment Management: Materials must be cleaned before transfer through the pass-through window; direct transfer from non-clean areas is prohibited. Internal equipment should be easy-to-clean and low-dusting models, regularly wiped and maintained to avoid dust pollution from equipment operation. Equipment maintenance must be performed outside the cleanroom or with comprehensive protection measures.

4. Daily Operation Control: When starting up, first activate the purification air conditioning and filtration system, run for more than 30 minutes before personnel enter for operations. During operation, monitor pressure differential, temperature, humidity, particle count and other data in real-time; immediately shut down for inspection if any abnormality is found. Before end of shift, stop production operations first, clean the indoor environment, then keep the purification system running at low speed or on timed start-stop to maintain positive indoor pressure.

5. Maintenance Requirements: Regularly clean pre-filters and medium-efficiency filters, replace HEPA filters according to usage cycles. Calibrate sensors and monitoring equipment monthly, conduct comprehensive cleanliness testing quarterly. Strictly prohibit unauthorized modification of enclosure structures, ventilation ducts, and control equipment; maintenance must be performed by professional personnel.

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4. Product Advantages

Strong Cleanliness Stability: Adopts multi-stage filtration and precise airflow design to stably maintain preset cleanliness levels 24/7, unaffected by external haze, dust, or temperature/humidity fluctuations. Thoroughly solves particle and bacterial contamination problems during production, ensuring product qualification rate.

Precise Controllable Parameters: Equipped with intelligent automatic control system, with high precision for core indicators such as temperature, humidity, pressure differential, and cleanliness. Can be flexibly customized and adjusted according to different process requirements, adapting to strict production standards across multiple industries, meeting refined operation requirements.

Energy-Saving and Consumption Optimization: Adopts high-efficiency purification units and rational airflow design, reducing energy consumption compared to traditional purification spaces. The system operates with low noise, paired with silent fans to create a comfortable working environment, balancing purification efficiency and operating costs.

High Customization Adaptability: Customized design solutions can be provided based on customer site area, production process, and cleanliness level requirements, covering from Class 100 to Class 1000000. Adapts to personalized cleanliness requirements of different industries and processes, with reasonable layout and high space utilization.

Comprehensive Safety Protection: Features positive pressure protection, anti-static, antibacterial and anti-mold, disinfection and sterilization multiple functions, effectively blocking cross-contamination, complying with GMP and safety production regulations for pharmaceutical, electronics, food and other industries, ensuring dual safety of personnel and products.

Convenient and Durable Operation & Maintenance: Uses corrosion-resistant, easy-to-clean, low-dusting high-quality enclosure materials with long service life. System modular design makes daily maintenance simple and filter replacement convenient, with full-process technical guidance and after-sales support, reducing long-term operation and maintenance costs.

5. Applicable Industries

Cleanrooms, with their strict environmental control capabilities, are widely applied across various industries that are highly sensitive to environmental contamination and require extremely high product precision. Core coverage areas include: **Semiconductor and Electronics Industry, Precision Machinery and Optics Industry, Medical and Health Industry, Food and Daily Chemical Industry, Research and Laboratory** and other fields.

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