

# BUBBLE TIGHT SPACES BEST PRACTICES GUIDE

## DESIGN CONSIDERATIONS FOR SMALL AND LARGE CLEAN ROOM APPLICATIONS

With full scale production of innovative new therapeutics like cell gene therapy drugs, significant corporate and government investment in semi-conductor production, and rapid growth of battery production, there has been a proliferation of both small and large footprint clean room production environments requiring ‘bubble tight’ spaces. These tight spaces have unique design attributes and considerations that can cause challenges for consulting engineers and contractors. Awareness of these application attributes and how to accommodate for them at the outset of design will help to avoid costly oversights and ensure peak performance of your critical environments from day one.

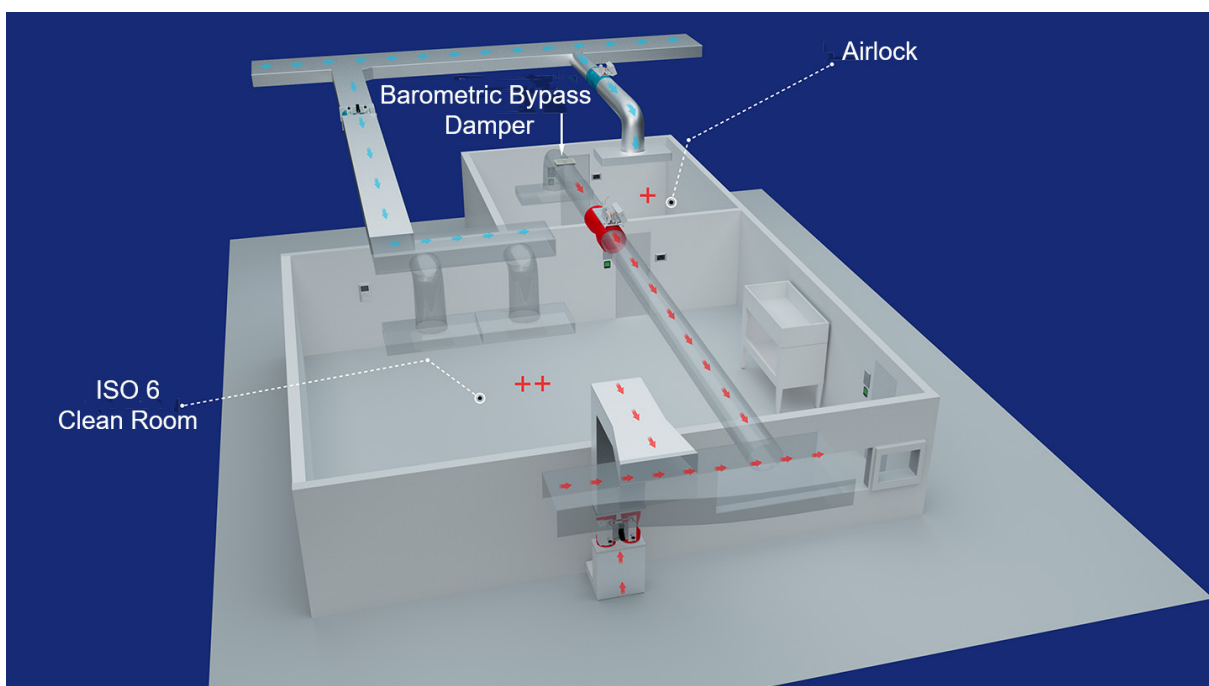
### Key Design Considerations

There are a lot of different layouts and approaches to clean rooms. How do you know if your specific clean room application could pose problems when being constructed? What are some of the difficulties that can crop up in a ‘bubble tight’ application. One attribute of small bubble tight applications is that they can cause tracking pair valves or other airflow control devices to lock up and move in sync, not providing an offset and throwing off proper balance of the space.

1. The construction of the space should be designed to withstand the pressure of a failed fan system where an uncontrolled supply fan, and/or exhaust fan could potentially cause the full force of the fans to be applied to the ductwork and surfaces within the space for an undetermined period of time without structural failure.

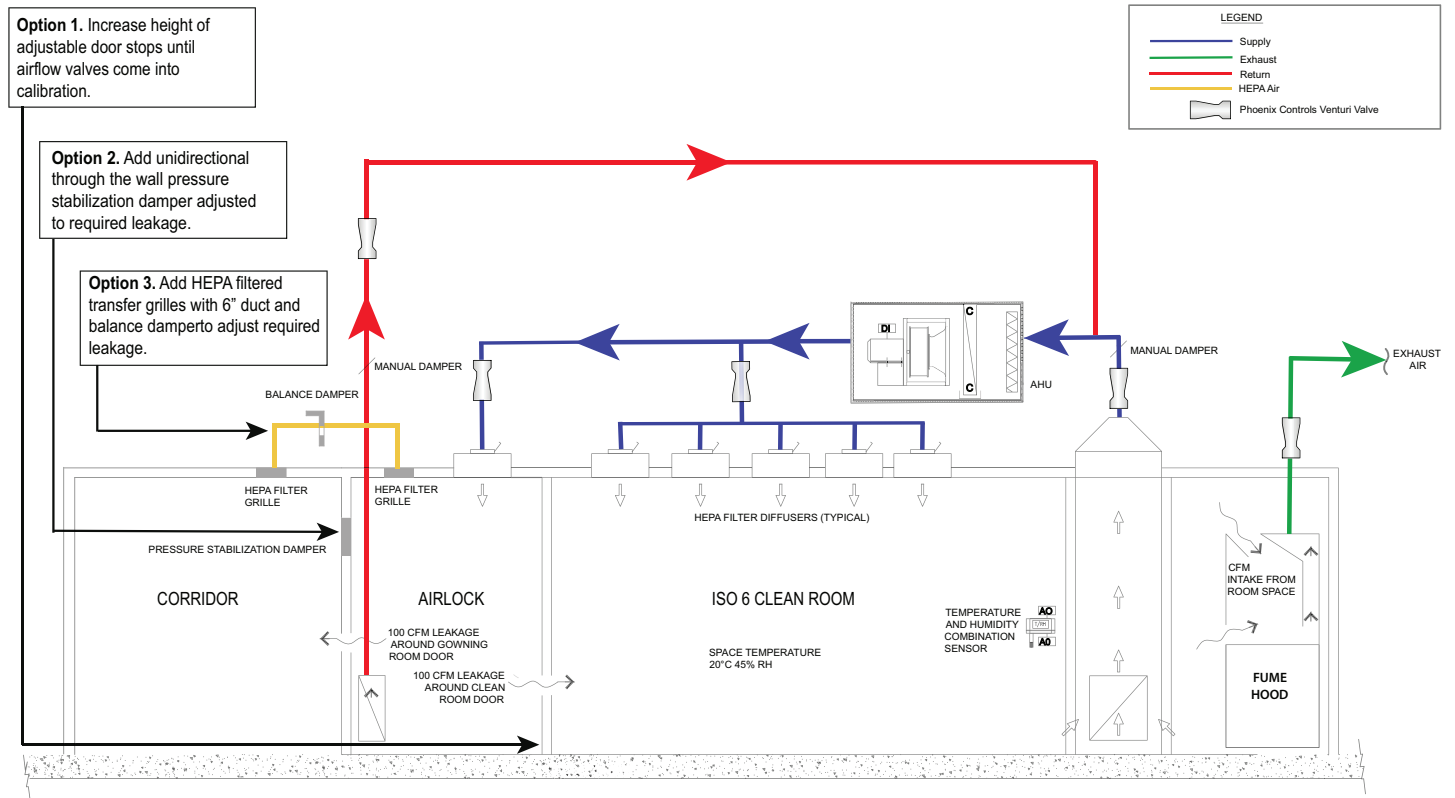
Note that as an alternative, some means of mechanical bi-directional over-pressure relief such as barometric dampers, can be incorporated into the room design. The Phoenix Controls solution can monitor status contacts on any over pressure device and use the input for alarming and to initiate a predetermined fail-safe mode.

Figure 1. Typical Clean Room with Cascading Pressures



- An adjustable method for leakage should be incorporated into the room design. If cross contamination is an issue the leakage path may be filtered. The Phoenix Controls solution can monitor differential pressure sensors across a filter to determine if it is clogged and generate an alarm. Overly tight spaces without a path for leakage may result in improper valve operation.

**Figure 2. Leakage Solution Options**



- It is strongly encouraged that all Phoenix valves used for control purposes be configured to fail-to-last position. Use of fail-to-open or fail-to-close is strongly discouraged.
- Phoenix control valves should be electronically clamped at flow settings that are within what is determined to be a safe operating range that will not over or under pressure the space in the event of device or control system failure.
- When considering pressure control, customers should consider and advise Phoenix Controls or their representative(s) of the relative importance of the following factors to determine an appropriate fail-safe- scheme:
  - Fume hood containment
  - Room containment
  - Ventilation
  - Temperature
  - Room Safety
- It is recommended that rooms with that these spaces with frequent and/or large changes in airflow rates utilize standard volumetric offset control.

## Qualifying Questions/Decision Tree

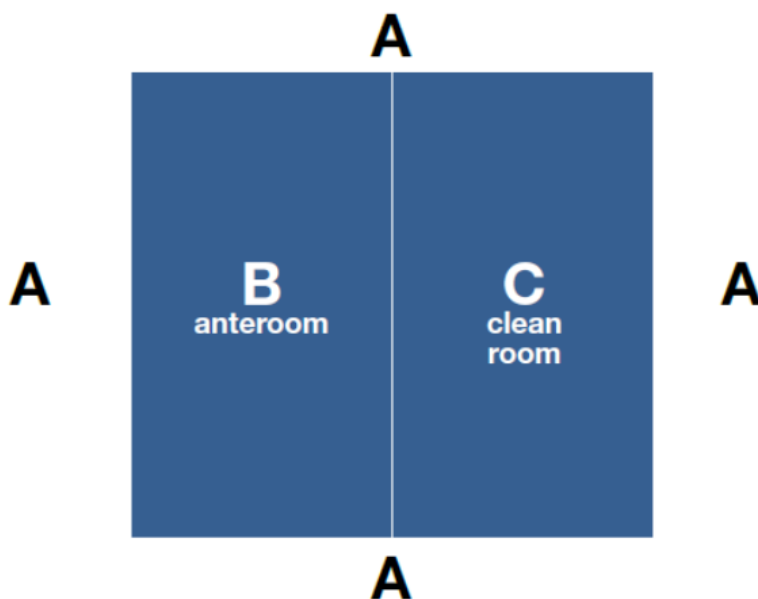
- Is my application space or room a 'tight' space, is it an airtight clean room application? That is, does it have little to no leakage?
- Do I have any 'bubble tight' spaces in my design? That is spaces that are positively pressurized relative to adjacent spaces which also may be positively pressurized, but less so relative to the space in question. See Figure 1.
- Are any of these 'bubble tight' spaces 100<sup>2</sup> or less?

## Resolution

If you answered yes to any of these questions you may face difficulty with tracking pairs syncing up in these smaller spaces. There are several effective approaches to ensure optimal operation upon commissioning and delivery.

1. Determine the required pressure differential between operating areas of the clean room with the entry corridor acting as a neutral reference. This required pressure difference must be noted as positive and negative and recorded in Pa or inches of water.

Figure 3. Pressure Diagram



Pressure differentials:		
Pressure differentials to be maintained at all times:	1)	$12.5 \text{ Pa} \geq (P_C - P_B) \geq 5.0$
	2)	$12.5 \text{ Pa} \geq (P_B - P_A) \geq 5.0$
<b>Legend:</b>		
	A = facilities environment	
	B = anteroom	
	C = clean room	
	P = pressure	
	Pa = pascal (SI unit of measure for pressure)	

2. Introduce leakage to the space or reduce leakage from the space by adjusting the door sweep drops to provide enough air for volumetric offset. Using door manufacturer data, determine the correct leakage rate for the desired pressure differential. See Figure 2, Option 1.

**Figure 4. Door Leakage Rates**

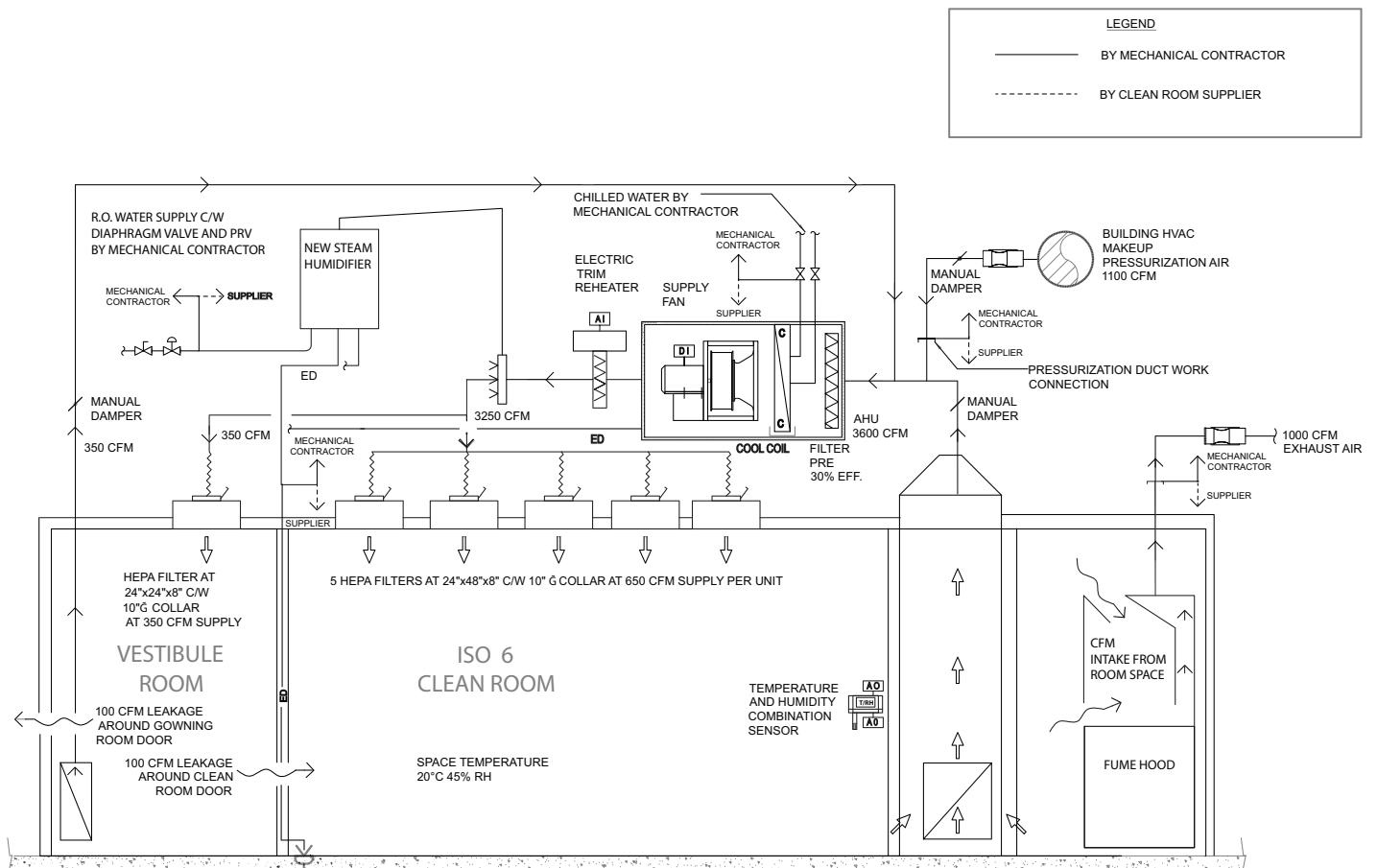
Door	Door Tag	WIC (in)	HIC (in)	Top Gap (in)	Bottom Gap (in)	Edge Gap (in)	Center Gap (in)	Area (in <sup>2</sup> )	Pressure (in H2O)	Velocity (mph)	Velocity (fpm)	Q (CFM)
415	D130-01	72	96	0.05	0.093	0.06	0	22.066	0.17	18	1584	133
615F	D130-02	72	84	0.075	0.093	0.093	0	28.37	0.07	12	1056	114
413	D130-03	36	84	0.025	0.093	0.025	0	8.448	0.17	18	1584	51
413	D137-01	36	84	0.025	0.093	0.025	0	8.448	0.1	14	1232	40
2502	D137-02	72	84	0.045	0.06	0.045	0	15.12	0.06	11	968	56
415	D136-01	72	96	0.05	0.093	0.06	0	22.066	0.04	9	792	67
2502	D078-01	76	96	0.045	0.06	0.045	0	16.62	0.2	20	1760	112
2502	D078-02	76	96	0.045	0.06	0.045	0	16.62	0.2	20	1760	112
2502	D078-03	60	84	0.045	0.06	0.045	0	13.86	0.02	6	528	28
413	D082-01	36	84	0.025	0.093	0.025	0	8.448	0.18	19	1672	54
2502	D082-02	60	84	0.045	0.06	0.045	0	13.86	0.14	17	1496	79
2502	D083-01	60	84	0.045	0.06	0.045	0	13.86	0.01	4	352	19
2502	D084-01	60	84	0.045	0.06	0.045	0	13.86	0.03	7	616	33

3. Estimate the room leakage (excluding doors) based on the pressure differential to the surrounding environment. For modular clean rooms with proper assembly, use 0 cfm for leakage in design. At the outset of design incorporate a Pressure Relief Vent or PRV to create a pathway for airflow to enable volumetric offset. See Figure 2, Option 2.
4. For applications where door leakage does not work as a solution, an adjustable through-the-wall PRV will provide the ability to dial in the room to the correct pressure differential. See Figure 2, Option 3.

**Example application of HEPA PRV's for BSL applications or rooms where door leakage is insufficient:**  
 Determine the required volumetric off-set to achieve the desired pressure differential. Select 50 cfm offset to start and adjust PRV to achieve pressure differential. If pressure differential cannot be met, increase volumetric offset to 100 cfm and repeat procedure. On the return or exhaust side, incorporate an inlet from the non-classified space to the supply valve to provide enough air and static pressure to enable control.

5. Using Phoenix volumetric offset control, enter the required supply air flow rate to meet ISO air change rate. Adjust the return and exhaust air flow rates to achieve the required pressure differential rate for the room. See Figure 5.

**Figure 5. Volumetric Offset Control**



### Phoenix Controls End-to-End Support

Phoenix Controls is an engineered solutions provider with a global network of partners experienced in providing comprehensive critical environment solutions that enable cutting edge technology for your customer at the lowest total cost of ownership. Engage us or one of our more than 70 partners worldwide to provide design assistance, consultation, and review, assuring your applications are functional, safe, and meet and exceed your customer’s requirements. With over 35 years experience providing air flow controls to critical environments in healthcare, laboratory, high-purity manufacturing, and pharmaceutical applications, Phoenix Controls devices are engineered to ensure environmental integrity, occupant safety, and cost-saving energy efficiency.