International Vaccine Development (INTERVAC) Centre at the University of Saskatchewan

There is a recognized shortage of Containment Level 3 Laboratories (CL3) in the world so InterVac was designed with this in mind. The intention is to make specialized research areas available for use by a variety of groups who require this level of capability to conduct the research and testing to further advance their pursuits. Additionally, the users of high level labs need an infrastructure support network, high level security, meeting spaces, offices, sophisticated operating systems, and many other features to facilitate the experimentation and documentation occurring at InterVac. As such, the design and construction team played a crucial role in delivering an end product that met regulatory requirements, functionality, and reliability.

Figure 1: Outside image of InterVac Centre at the University of Saskatchewan

Figure 2: Intervac CL2 Lab Space

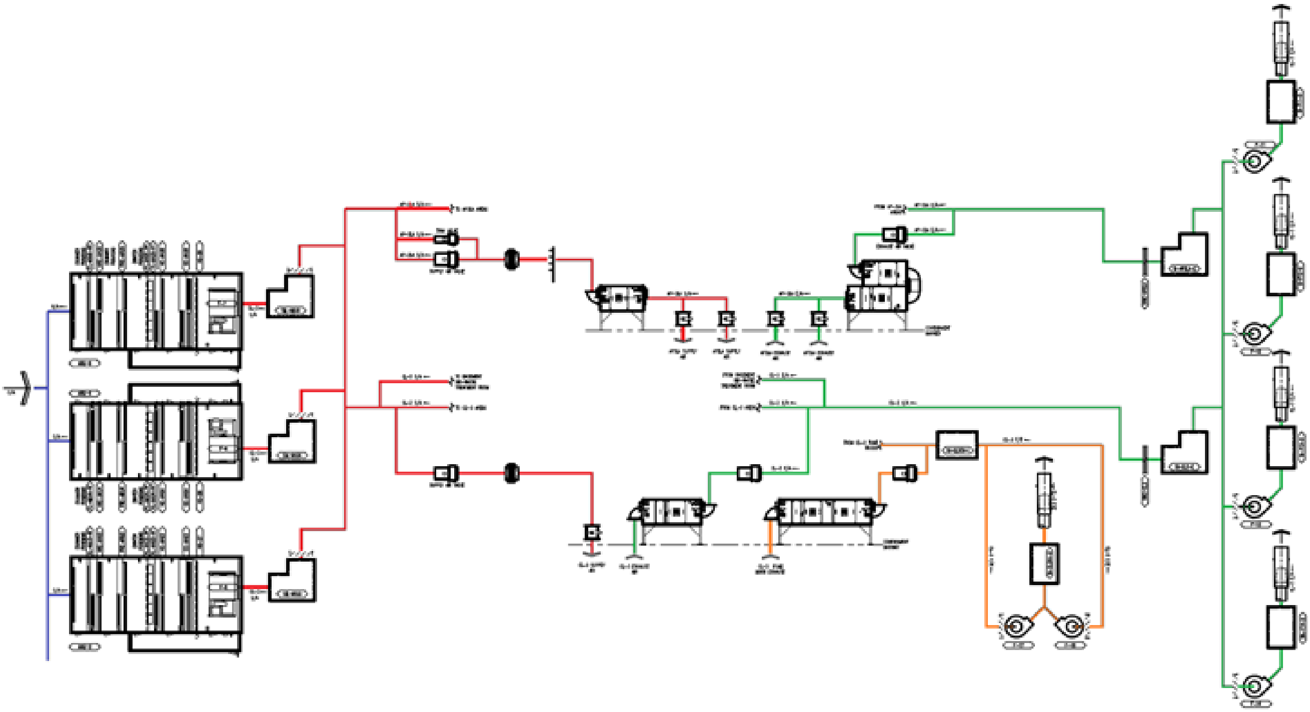

Figure 3: CL3 and CL3-AG Ventilation System Schematic

The supply air system required 25,820 L/s (54,700 CFM) of air to be provided to the lab space. 3 Air Handling Units (AHUs) were designed; each having the capacity to provide 50% of the total air flow under emergency conditions, but each providing 33% during regular operation. Similarly, four exhaust air fans were selected to each provide 25% of the required flow, but ready to increase to 33% each if required.

The air systems to the lab were designed to operate at 100% outdoor air. By not recirculating lab air, the risk of cross contamination is greatly reduced. The odours normally associated with lab chemicals are also not recirculated. However, a 100% Outdoor Air system is very energy intensive. To reduce the energy footprint associated with the air system, a glycol heat recovery system was installed to reclaim some of the energy from the exhaust air stream.

Air Filtration

When providing ventilation to a CL3 or CL3-AG containment laboratory, all exhaust air is required to be HEPA-filtered. To avoid an instance of a pressure reversal, an effective method of back-draft control is also required to prevent potential contaminants escaping out of the supply air system. For the CL3 lab areas, a single exhaust HEPA filter were provided as required above. However, the ventilation systems for the CL3-AG labs were instead designed to the more rigorous CL-4 standard. For this level of lab, the exhaust air is drawn through two HEPA filters in series. This second HEPA captures any contaminants which could happen to pass through the first HEPA filter due to damage or defect. Similarly, a HEPA filter is also installed on the supply air to create a containment barrier.

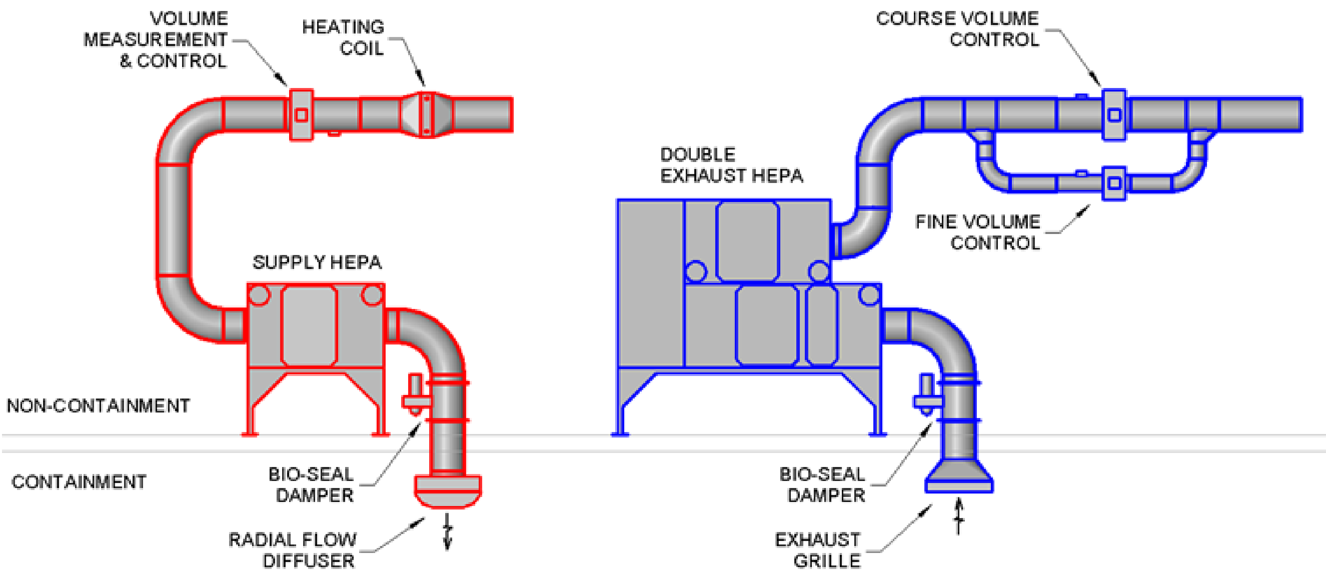

Figure 4: The CL3-AG lab spaces were designed to meet CL4 HEPA filter requirements

For both the CL3 and CL3-AG labs, a “bubble tight” Bio-seal damper was installed at the containment barrier. This damper can be closed in case of a lab shutdown for decontamination, emergency, or when the lab is simply not in use. When these dampers are closed, the containment suites are able to pass an air pressure decay test to prove the integrity of the Lab.

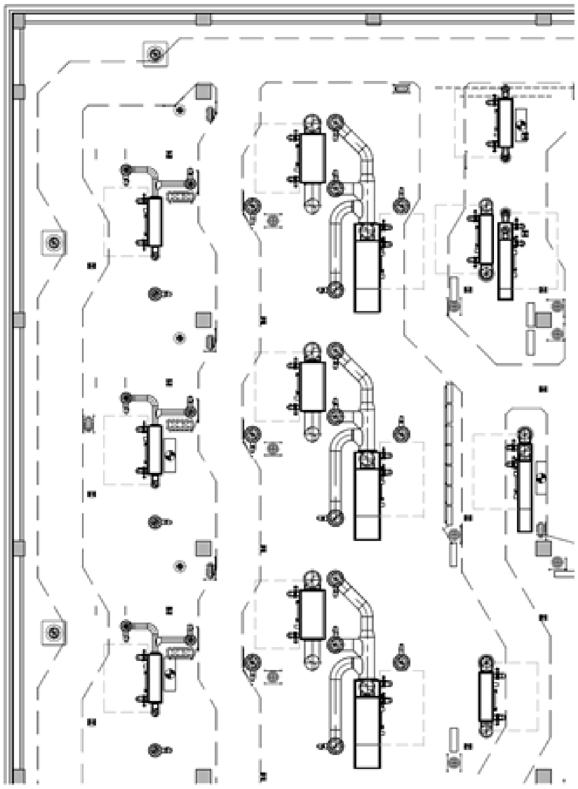

Figure 5.1: HEPA Filter Floor showing cart path

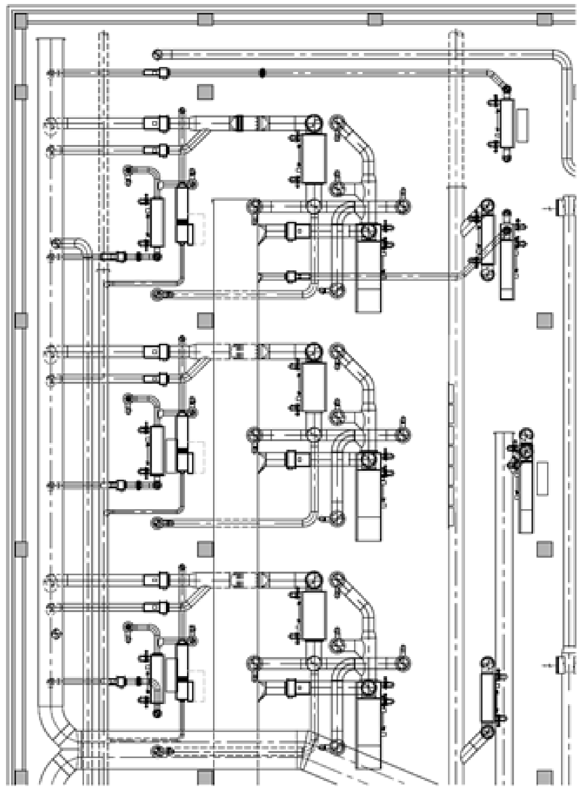

Figure 5.2: Upper Elevation showing inter-connecting ductwork

A mechanical floor was designed above the lab suites to provide maintenance access to the many HEPA filters, flow controls, humidification equipment, and the other services. This greatly eases the difficulty associated with filter changes, decontamination, and other maintenance activities required. In order to clearly visualize the equipment in relation to the lab spaces below, wall lines and room numbers were painted on the floors to indicate the floor plan below.

Layout and configuration of the HEPA filter floor was an extremely challenging engineering exercise. Coordination was required between the grille and diffuser locations below, and the HEPA filter housings above. A "Cart Path" was laid out to ensure that every HEPA filter would be accessible to the maintenance staff.

When locating the HEPA filter housings, previous lab generations placed individual HEPA filter housings for each penetration through the containment barrier. This design strategy would create a huge capital expense, and frustration in developing a functional layout due to the large number of HEPA housings required. This strategy was revised for this next generation of lab. Here, a single larger HEPA Housing would serve multiple penetrations through the containment barrier thereby greatly reducing the number of HEPA housings required. In this configuration, a few meters of ductwork becomes part of the containment barrier, and thus is designed to be constructed of thick gauge, type 304 welded stainless steel. This ductwork must also pass the lab pressure decay test, thus a high degree of workmanship is required on the installation. No leakage is allowed on these systems.

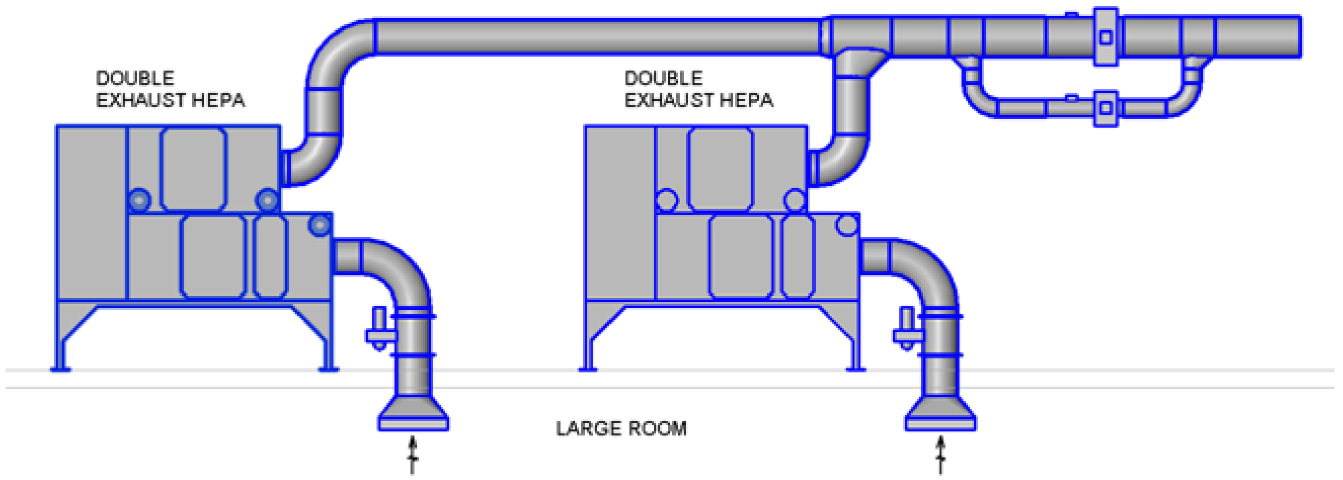

Figure 6: Previous generation HEPA configuration. One HEPA Housing per Penetration

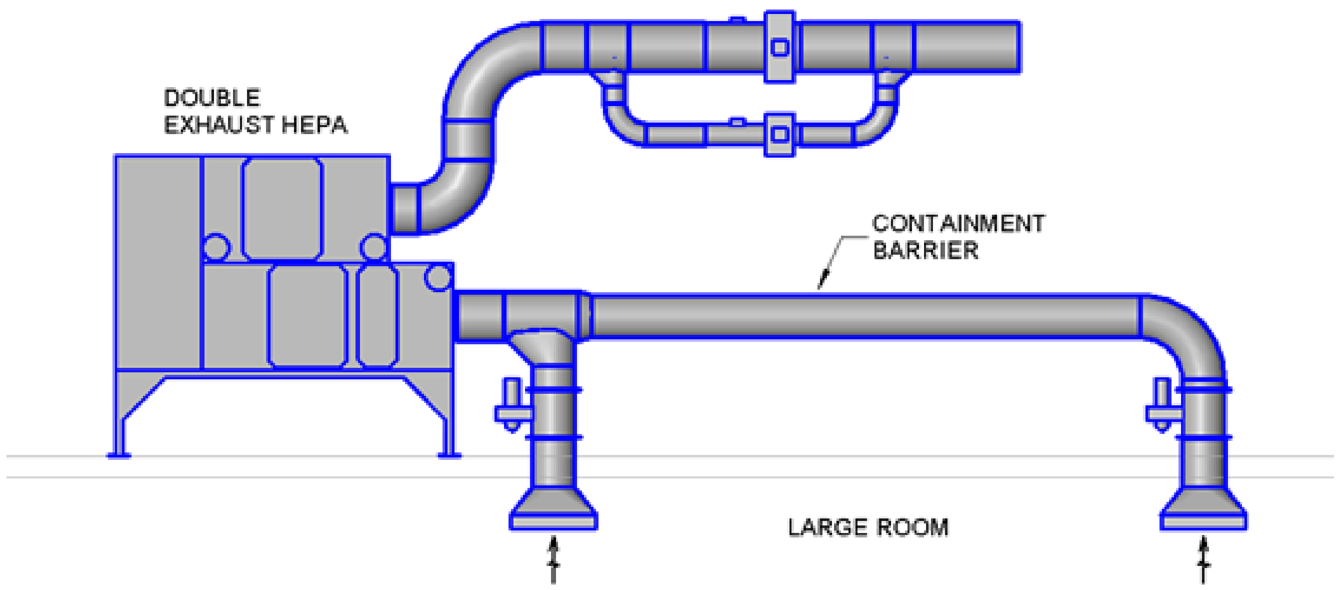

Figure 7: Next generation HEPA configuration. Welded Stainless Steel ductwork as part of the containment barrier

With the number of HEPA filters greatly reduced, the capital savings of these HEPAs could be reinvested into purchasing the next generation of HEPA filter housings. These housings, while more costly, were equipped with integral bio-seal dampers, decontamination ports, and a state of the art "autoscan" feature. The Autoscan allows the HEPA filter performance to be verified, and tracked over time thereby giving the lab operators and certification agency the validation reports they require. This feature also provides substantial labour savings in performing these tests.

Figure 8: Next generation HEPA housing with integral bio seal dampers, and Autoscan technology

Another test required by the Lab certification agency is a room pressure decay test. In this test, the lab space is placed under negative pressure and the ductwork is sealed with the bio-seal dampers. To pass this test the room pressure must not rise from -500 Pa (-2" W.C) to -250 Pa (-1 "W.C) over the course of 20 minutes. This test proves the integrity of the entire containment barrier and ensures that the containment is established. In order to pass this test, the highest standards of design and detailing is required for every service penetration through the containment barrier is tightly sealed.

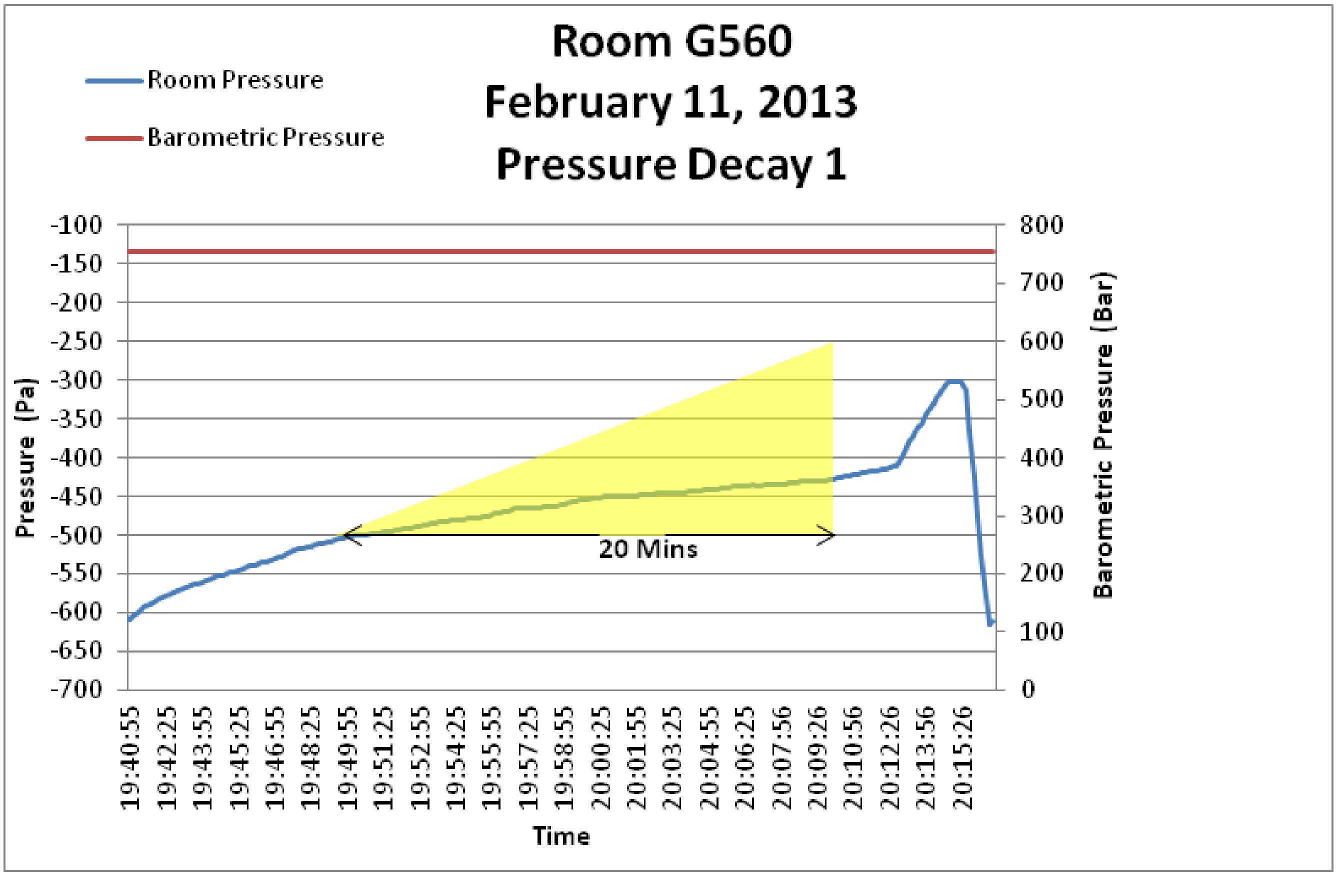

Figure 9: Room Pressure Decay Test. This lab space passed the test requirements

Lab Pressurization and Control

One key to ensuring proper containment in a Lab suite is proper relative pressurization between clean and dirty spaces. The dirtier or more contaminated the space, the lower the air pressure. This ensures that any potential leakage through the containment barrier will be inward and not outward.

The central dirty corridor, used for waste removal, is kept at -200 Pa (0.8" W.C.), while the lab suites are kept at -150 Pa (0.6" W.C.). The clean corridor around the lab suites is kept at -50 Pa (0.2" W.C.). All pressures are relative to outdoor air. An airlock used for decontamination and pressure control is located between the Lab space and clean corridor so that operators could easily open the doors against this differential pressure.

Control of the mechanical air flow equipment is critical in safe lab operation. To ensure that the spaces maintain their pressure set points and can quickly and accurately react to changing conditions both inside and/or outside the labs, a combination of open loop and closed loop control strategies are used. The open loop strategy provides course control and is fast-acting, while the closed loop strategy provides fine control and is more accurate.

Bladder-style Teck Air valves are used to measure and control the flow of air into and out of each lab space. The quick response and control linearity made these valves an excellent choice for this application. The exhaust air valves are modulated to provide the required air flow to achieve the required room air change rates. The supply air valve simply tracks the exhaust air flow rate with a differential offset to achieve a negative pressure inside the lab. This open loop control strategy is effective and fast-acting. However, to achieve tighter control over the room pressures, a second smaller air valve, called the "trim valve", is installed on the supply duct to act in parallel to the main supply valve. The trim valve modulates based on actual room pressures and adjusts as required to maintain the room pressure set point. This provides the closed loop control function, and ensures accuracy.

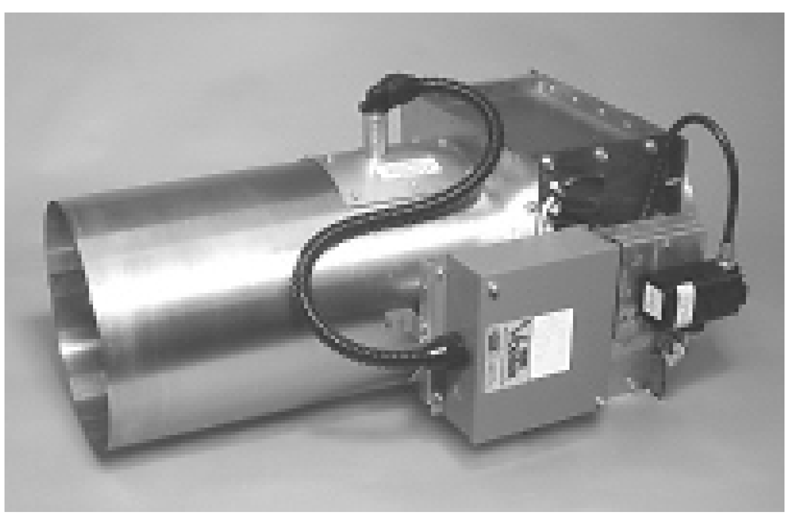

Figure 10: Bladder style Tec-Air Control Valve