**IsolationAir® System Testing for Usage in Surge Capacity Hospital Rooms**

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Study Objective:

As a result of the Covid-19 pandemic, there is an increased awareness for the need of surge capacity temporary isolation spaces. Having an ample number of “on demand” isolation environments is crucial during a pandemic or event that greatly increases demand for hospital beds. Depending on the type of sickness a patient has, it is important to be able to quickly create a clean negative or positive pressure environment. The CDC guidelines for isolation spaces include a minimum of 12 air changes per hour, a minimum negative pressure delta of 0.01” with the surrounding space, and a significant reduction in particles (0.5 µm and larger) via use of a HEPA filter. The objective of this study was to show how a portable isolation unit can dramatically reduce particle counts inside surge capacity hospital rooms and meet the CDC guidelines listed above.

Materials and Method:

The IsolationAir® System (Air Innovations, Syracuse, NY) creates positive or negative pressure through air-ducting mechanisms. The system also maintains room temperature and uses HEPA filtration and ultra-violet light to remove air contaminants within the patient room. Once familiar with the equipment and room, installation of the unit takes approximately 30 minutes.

An IsolationAir® unit was installed and tested on June 9$^{th}$, 2020, in a “pop up” hospital room at the Berkshire Innovation Center in Pittsfield, Massachusetts. The room used for the testing was made from double-walled 5/8” thick corrugated cardboard. The room had an area of 78.86 sqft with close to 8’ ceilings, giving the room a total volume of 618.225 cuft. Aluminum brackets along the outside edges secured the cardboard pieces together, and a plexiglass ceiling and window allowed for sufficient natural lighting. Full height double doors were located at the right front corner of the room with door sweeps to insure a tight seal. The bed, also constructed from corrugated cardboard, was positioned in the left back corner of the room. Across from it, in the right corner, stood the IsolationAir® unit. Two 10” ducts were built into the right back corner of the room about 6’ off the ground so that the IsolationAir® system had the necessary ducts to operate. The ducts were set up at 90-degree angles from each other to minimize interaction between the supply and exhaust airflows. A detailed layout of the room is shown in Figure 1, and the duct installation is shown in Figures 3 and 4.

Figure 1: Diagram of Room

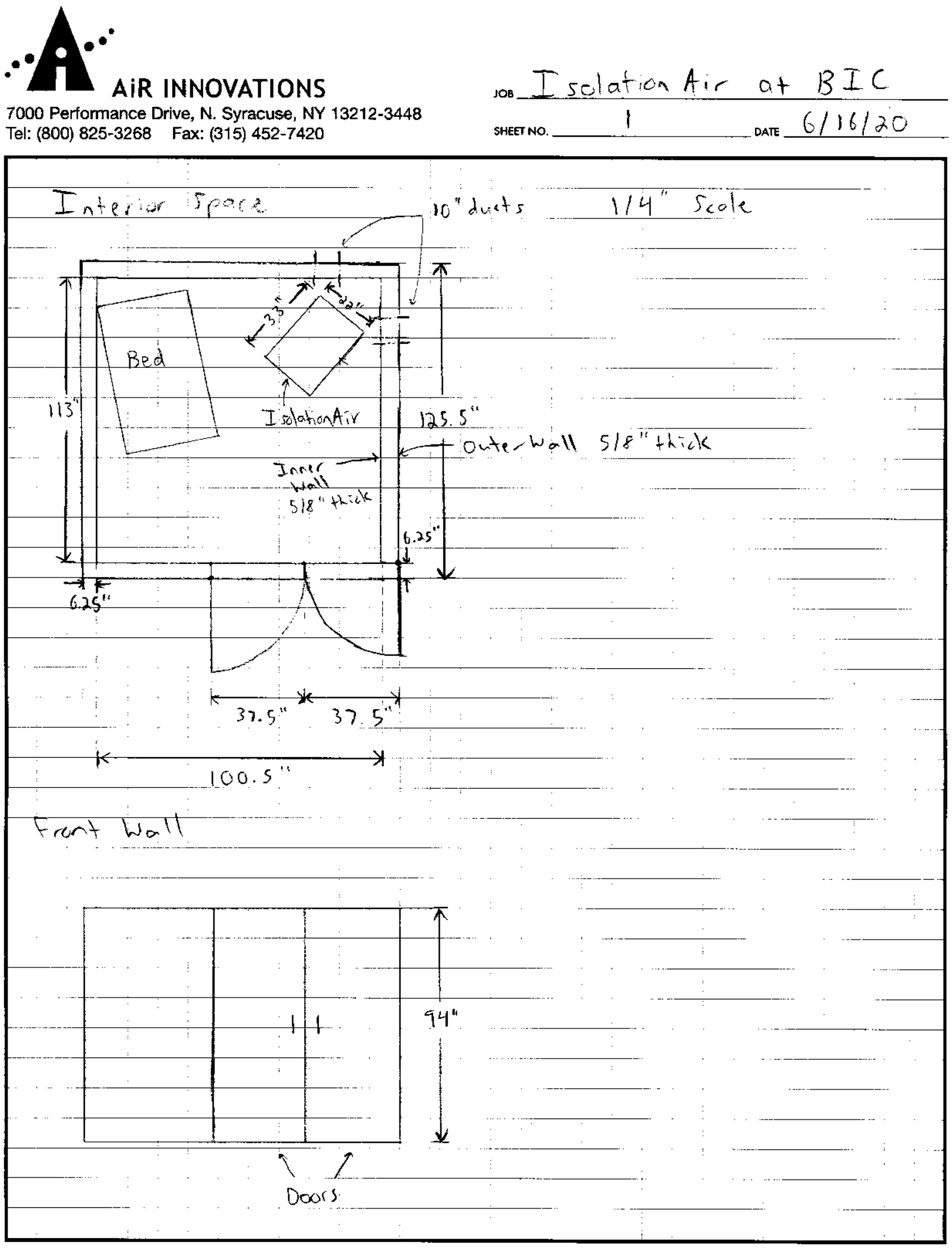


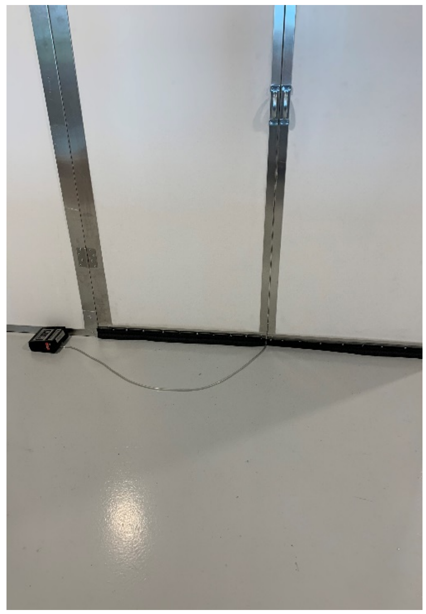
Figure 2: Room Before Installation

The Particles Plus® 8303 Handheld Particle Counter was set up on the bed to read particle counts over time. It was stationed 4' away from the IsolationAir® system. The counter operates at 0.1 cfm, and the sample time can be adjusted to best suit the user. The counter measures particle sizes of 0.3, 0.5 and 1 µm in both differential and sum format. Differential format counts the number of particles between each particle size, while sum counts the total number of particles of a certain size or larger. A USB drive was used to export the data from the counter into Excel, where the particle count data over time could be viewed graphically. The particle counter standing on the bed is shown in Figure 5.

Figure 3: Particle Counter

An AirData™ Multimeter ADM-860 was used to prove a sufficient pressure delta between the isolation space and surrounding area was created after several minutes of the IsolationAir® system operation. Initially, the room was not sealed well enough to create a sufficient gradient, so duct tape was used to seal off large gaps between sections or the corrugated paper walls. For negative pressure operation, the goal was to create a minimum of 0.03” pressure gradient between the inside and outside of the space. For positive pressure, the goal was to create at least a 0.01” gradient. The pressure sensor setup is shown in Figure 6.

Figure 4: Pressure Sensor Setup



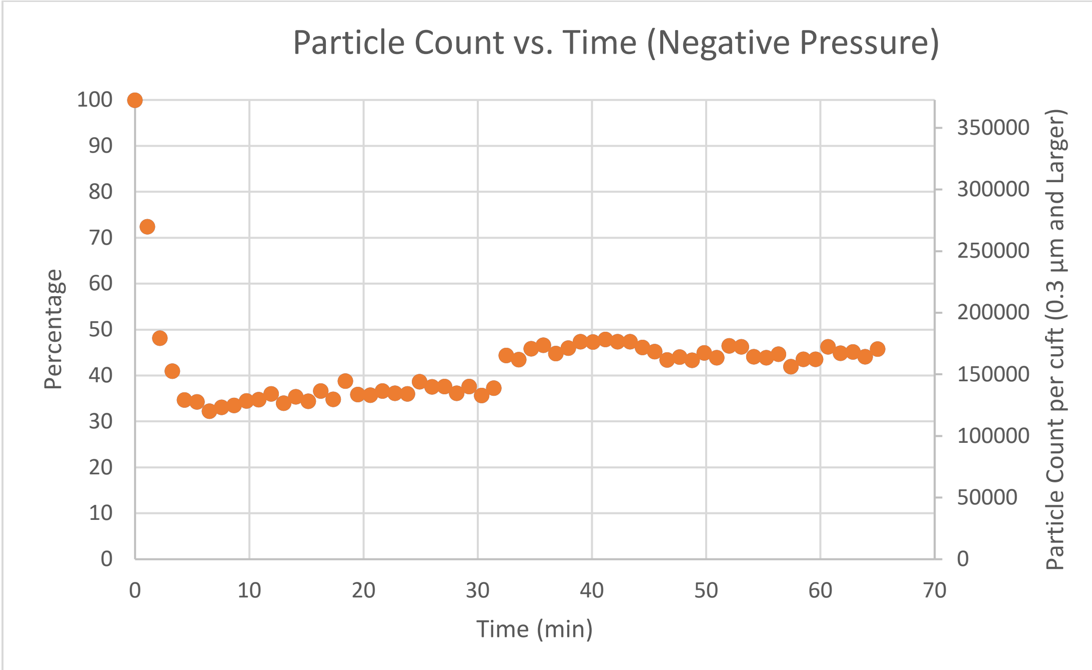
A 65-minute test was performed for both negative and positive pressure conditions. During each test, sixty 1-minute particle count samples were taken with a hold of 5 seconds between each sample. Pressure was measured about 5 minutes into the test to make sure a sufficient delta with the surrounding space was reached. At 30 minutes, the tester entered the room check the system, while also providing a rough simulation of a person entering the patient’s room.

Negative Pressure Test Results and Analysis:

Figure 5: Room After Installation for Negative Pressure

In the negative pressure test, an equilibrium was reached at around 35 percent of the initial particle count after 5 minutes of operation. The initial count for particles 0.3 µm and larger was 372650 particles, and the equilibrium number was approximately 128000 particles. An equilibrium pressure of 0.030" was reached around the same time, which well exceeds the CDC guidelines. There is a clear spike in particle count when the tester briefly entered the room at the 30-minute mark. Soon after the tester left, a new equilibrium was quickly reached at around 45 percent of the initial particle count. The increased number of particles in the second equilibrium may be explained by a leakage formed around the time the tester entered the room. After the test it was noticed that the grill adapter had pulled away from the wall, creating a gap that allowed more dirty air to flow into the room. It is also possible that the door was not sealed quite as tight after the tester exited the room, further explaining the new equilibrium value. Regardless, a significant decrease in particle count was still observed. Figure 6 shows the particle counts over the 65-minute negative pressure test as both a percentage of the initial particle count and the total number of particles over time.

Figure 6




The chart below shows the key performance data collected for the negative pressure test. Note how quickly the environment reaches equilibrium as a result of the high number of air changes per hour.

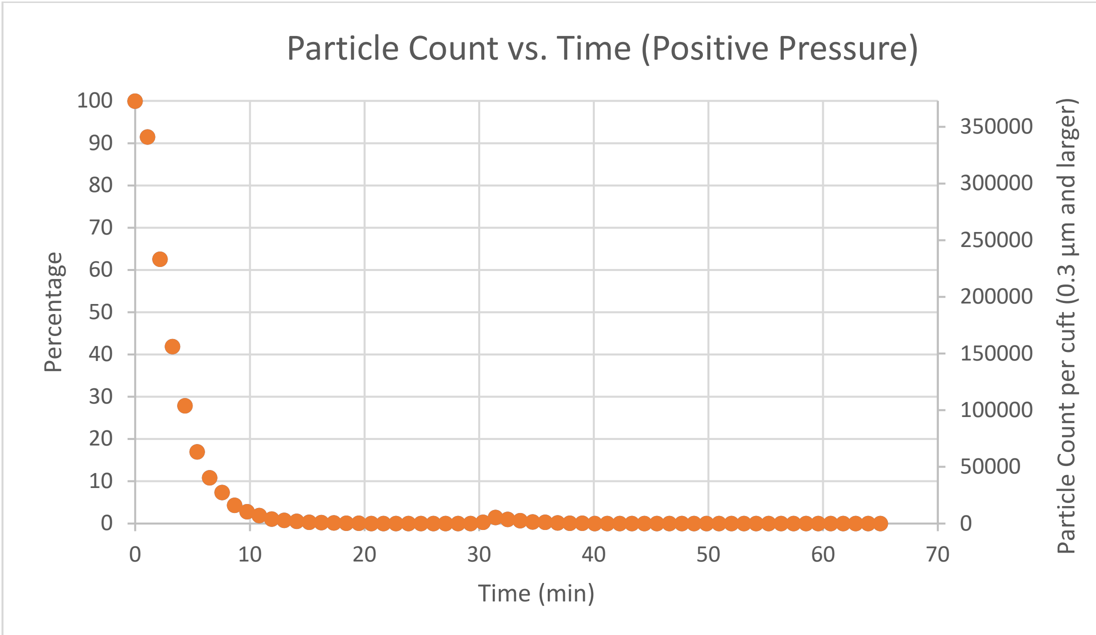
| **Performance** | |
|---|---|
| Air Changes Per Hour | 60 |
| Pressure Control | -0.03” |
| Particle Reduction (per cubic ft) | Equilibrium reached in 5 min. 372650 to ≈128000 particles/cuft. in 5 min. |

Positive Pressure Test Results and Analysis:

Figure 7: Room After Installation for Positive Pressure

In the positive pressure test, equilibrium was reached at virtually zero percent of the initial particle count. The initial count for particles 0.3 µm and larger was 372890 particles, and this number dropped to virtually 0 at equilibrium. An equilibrium pressure of 0.02” was reached within minutes. There is a subtle spike in particle count when the tester entered the room at 30 minutes, but the count quickly drops back off to just above zero percent of the initial count when the tester leaves the room and closes the door. Figure 8 shows the particle counts over the 65-minute positive pressure test as both a percentage of the initial particle count and the total number of particles over time.

Figure 8




The following chart gives the key performance data collected for the positive test.

| **Performance** | |
|---|---|
| Air Changes Per Hour | 30 |
| Pressure Control | 0.02" |
| Particle Reduction (per cubic ft) | Equilibrium reached in 15 min. 372890 to ≈0 particles/cuft in 15 min. |

Conclusion:

The IsolationAir® system creates positive and negative pressure isolation environments that meet or exceed the CDC isolation space guidelines for pressure management, particle count reduction, and air changes per hour. This system can be very effective in both surge capacity temporary hospital rooms and permanent isolation spaces. The unit acts quickly in reducing particle counts, reaching an equilibrium in under 15 minutes in the test room for positive pressure and in under 5 minutes for negative pressure.