

Application Note:

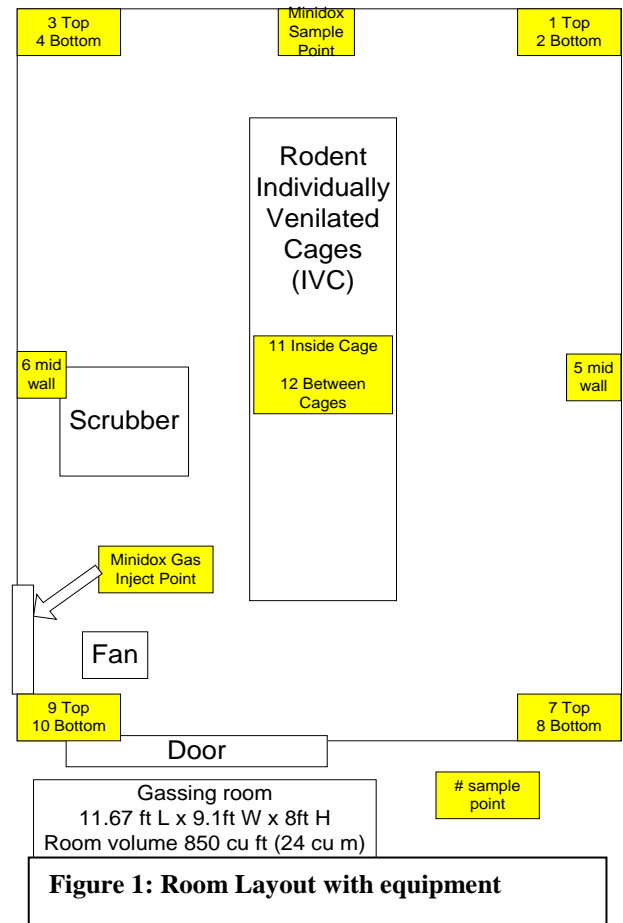
Chlorine dioxide gas diffusion and distribution

Chlorine dioxide (CD) is a true gas at room temperatures. As such CD gas gets complete distribution and penetration which is key for any decontamination to be effective. The below information documents the good distribution attributes of a true gas.

Tests:

To show excellent distribution of a gas, CD gas was injected into various room configurations, from empty room to equipment in the room (IVC racks) to plastic bisecting the room. Small fans were tested along with compact fans and even NO fan was tested. CD gas was injected using the Minidox-M CD gas generator and was measured in all corners of the room and inside the IVC rack using the EMS concentration monitor. Below describe the various room configurations.

1. Configuration 1 - Empty Room, Vornado Fan. In this configuration there was no equipment in the room other than the vornado fan and scrubber to remove the gas.
2. Configuration 2 - Empty Room, Compact Fan. In this configuration there was no equipment in the room other than the compact fan and scrubber to remove the gas.
3. Configuration 3 - Empty Room, No Fan. In this configuration there was no equipment in the room other than the scrubber to remove the gas.
4. Configuration 4 - IVC Rack, IVC Rack OFF, Vornado Fan. In this configuration the IVC rack was placed in the middle of the room (see pictures and diagram below). The vornado fan and scrubber (to remove the gas) were in the room also. The IVC rack was turned off.
5. Configuration 5 - IVC Rack, IVC Rack OFF, Compact Fan. In this configuration the IVC rack was placed in the middle of the room (see pictures and diagram below). The compact fan and scrubber (to remove the gas) were in the room also. The IVC rack was turned off.
6. Configuration 6 - IVC Rack, IVC Rack OFF, NO Fan. In this configuration the IVC rack was placed in the middle of the room (see pictures and diagram below). The scrubber (to remove the gas) was in the room also. The IVC rack was turned off.
7. Configuration 7 - IVC Rack, IVC Rack ON, Vornado Fan. In this configuration the IVC rack was placed in the middle of the room (see pictures and diagram below). The vornado fan and scrubber (to remove the gas) were in the room also. The IVC rack was turned ON providing air circulation within the rodent cages.
8. Configuration 8 - IVC Rack, IVC Rack OFF, Plastic Sheet bisecting room, - Vornado Fan. In this configuration the IVC rack was placed in the middle of the room and plastic sheeting was hung from the ceiling to the floor and from the back wall to the front wall (see pictures and diagram below). The vornado fan and scrubber (to remove the gas) were in the room also. The IVC rack was turned off.



9. Configuration 9 IVC Rack in Center, IVC Rack OFF, Plastic Sheet bisecting room, Compact Fan. In this configuration the IVC rack was placed in the middle of the room and plastic sheeting was hung from the ceiling to the floor and from the back wall to the front wall (see pictures and diagram below). The compact fan and scrubber (to remove the gas) were in the room also. The IVC rack was turned off.
10. Configuration 10 - IVC Rack in Center, IVC Rack OFF, Plastic Sheet bisecting room, No Fan. In this configuration the IVC rack was placed in the middle of the room and plastic sheeting was hung from the ceiling to the floor and from the back wall to the front wall (see pictures and diagram below). The scrubber (to remove the gas) was in the room also. The IVC rack was turned off.

Method

The 850 cu ft. room was prepared various configurations and with sensors in various locations (corners and center room) (see figure 1) then gas was injected and measured. Equipment was placed in the room and different fans were used to test distribution. The configurations were tested with a small Vornado fan then with a smaller compact axial fan and finally with NO fan.

Material and Equipment

1. ClorDiSys Solutions’ Minidox-M Chlorine Dioxide gas generator (MM-10A-2009)
2. Gassing Room 850 cu ft. (24 cu m), 11.67ft L x 9.1ft W x 8ft H (3.6m L x 2.8m W x 2.4m H)
3. EMS (EMS-06A-2015) with 12 sample points (3 manifolds of 5 Burkert kynar valves)
4. Qty 1 – Vornado 530W circulation fan, 283 CFM, blade diameter 7.17” (182mm)
5. Qty 1 – EBM PAPST 8500VW compact axial fan, 35.9 CFM, fan diameter 3.14” (80mm)
6. Thoren Caging System Maxi-Miser® Rack Systems, IVC Rack (Individually Ventilted Cage)
7. ClorDiSys Solutions Room Scrubber
8. ¼” polyethylene tubing (red)



Vornado 530W



Compact Ebm-papst axial fan

Gas Sample Points

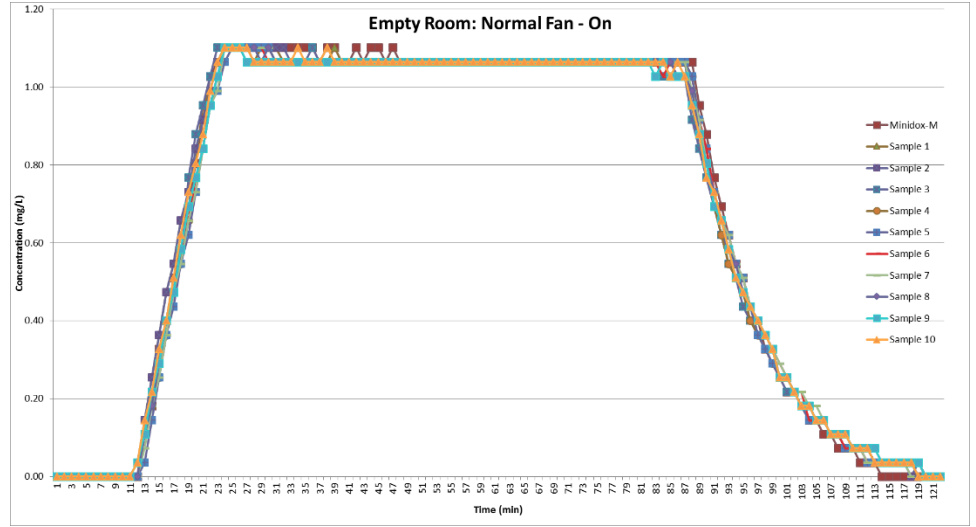
CD gas sample points were in all 4 corners, near the floor and near the ceiling, the middle of the room and equipment. *1- Top back right corner, 2- bottom back right corner, 3- top back left corner, 4- bottom back left corner, 5- right side middle of room half way up the wall, 6- left side middle of room half way up the wall, 7- Top front right corner, 8- bottom front right corner, 9- top front left corner, 10- bottom front left corner, 11- inside cage in the middle right side rack, 12- between cages in the middle of the rack.*

See figures below for sample location pictures.

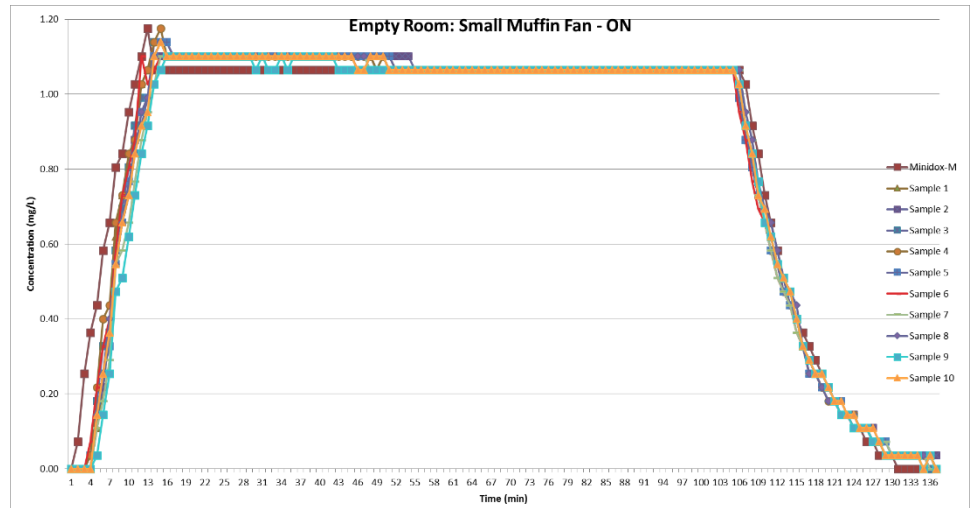
Results Empty Room

The below results show gas distribution in an empty room with no equipment. The room is 850 cu ft (24 cu m) with dimension of 11.67ft L x 9.1ft W x 8ft H (3.6m L x 2.8m W x 2.4m H). there was NO equipment in the room during this testing.

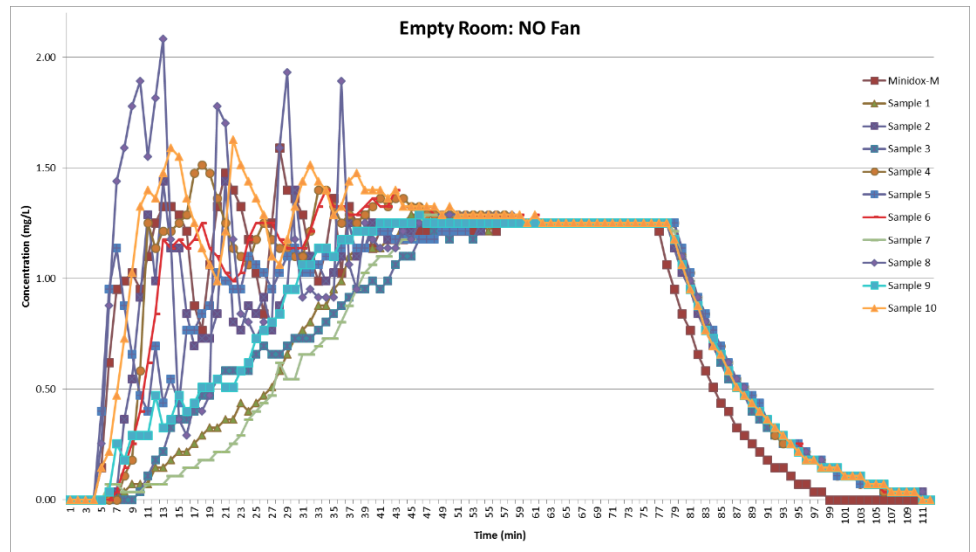
Configuration 1 testing was done with an empty room and the Vornado 530W fan. The distribution of all 10 readings closely follow each other reading. This shows good distribution with small fan.



Configuration 2 testing was done with a smaller fan to test the effect of different fans. With this configuration distribution was also good with equal gas distributed throughout the space.



In **configuration 3** NO fan was placed into the room. In this configuration, gas does eventually distribute throughout the space, but it takes time for this distribution to occur. Charge time for the room is approximately 15 minutes and gas concentration stabilized at minute 50. So gas distribution via only diffusion was achieved in 35 minutes with NO fan.



Results IVC Room

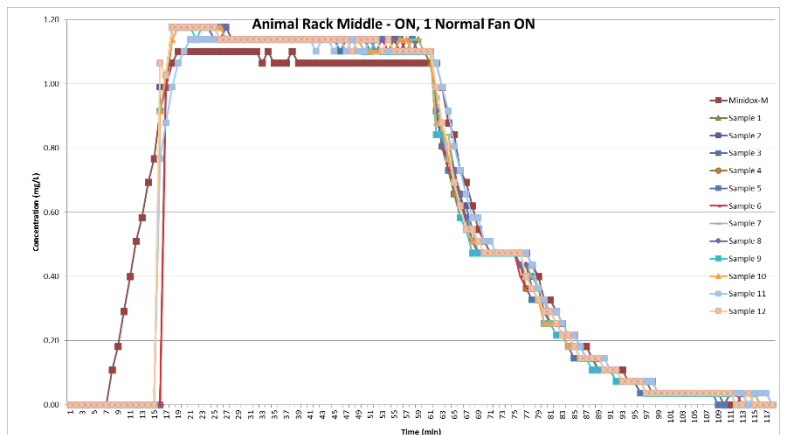
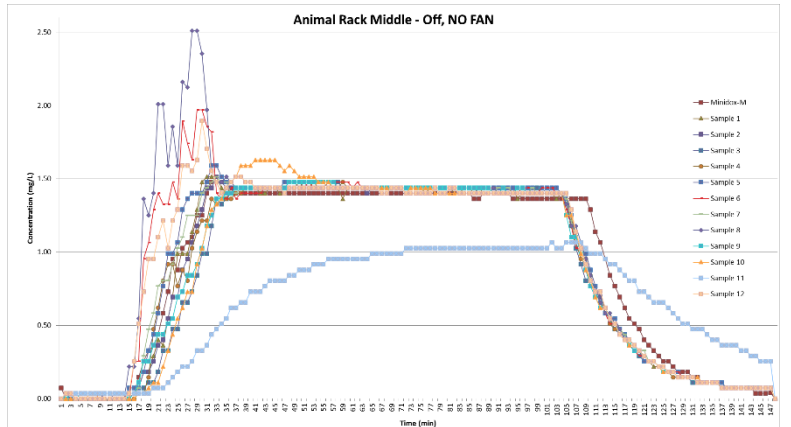
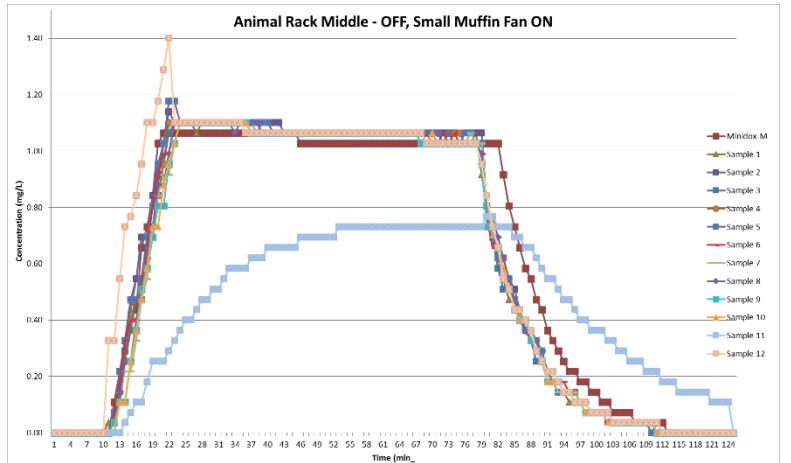
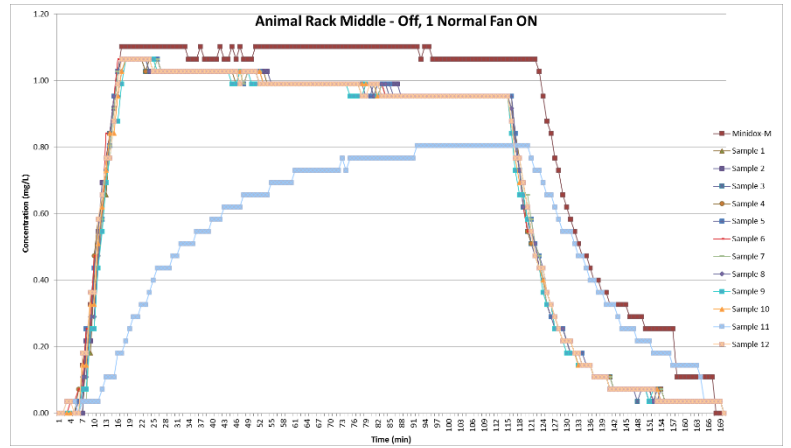
The below results show gas distribution in the same room as above, but with an IVC rack placed in the center of the room to block air flow. Two additional gas sample points were added (inside a cage in the middle of the rack and in the middle of the rack, 11 & 12)

In **Configuration 4** an IVC Rack in the center of the room with the rack turned off and the Vornado 530W fan. The distribution of 11 readings closely follow each other reading. Sample 11 was inside the IVC cage and the rack was turned off, so gas slowly diffused into the cage.

Configuration 5 testing was done the same a configuration 4 with a smaller fan to test the effect of different fans. With this configuration distribution was also good with equal gas distributed throughout the space.

Configuration 6 testing was done the same a configuration 4 with NO fan. In this configuration gas does eventually distribute throughout the space, but it takes time for this distribution to occur. Charge time for the room is approximately 15 minutes and gas concentration stabilized at minute 50. So gas distribution was achieved in 35 minutes with NO fan. This gas distribution was similar to configuration 3, demonstrating that equipment does NOT block the flow of gas.

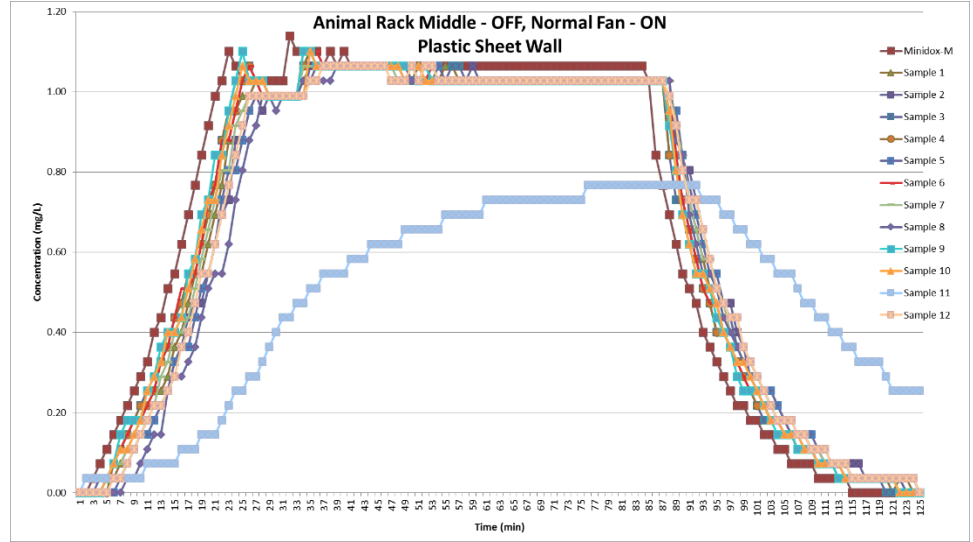
Configuration 7 testing was done the same a configuration 4 with the IVC turned on to bring in air flow to all rodent cages. This can be see by sample 11 not lagging behind the other samples as in configuration 4 readings.



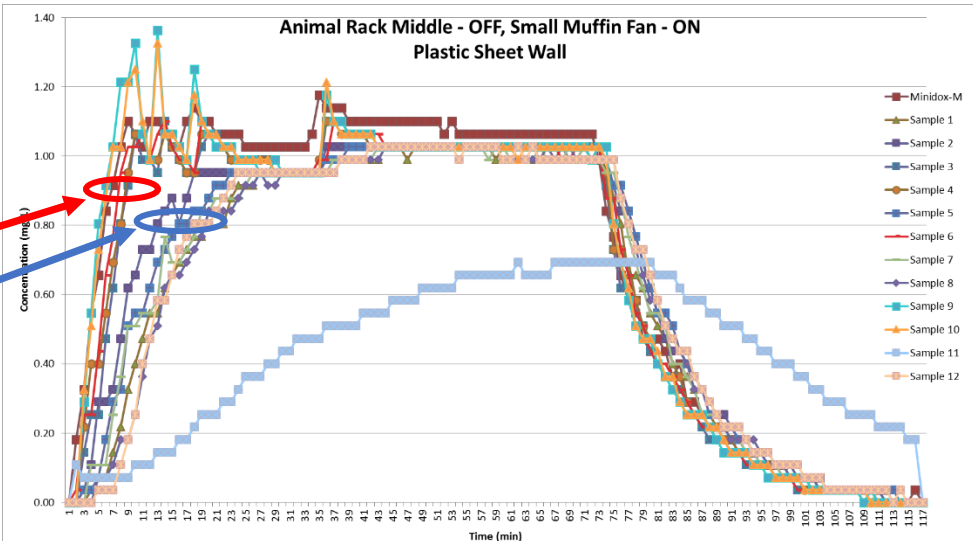
Results IVC Room with Plastic Sheet

The below results show gas distribution in the same room as above, but with an IVC rack placed in the center of the room and a sheet of plastic taped to the ceiling to the floor and from the front of the room to the back. It was only taped to hold the plastic in place to completely bisect the room in half. It was not taped to seal the spaces. See figures 3 & 4 below.

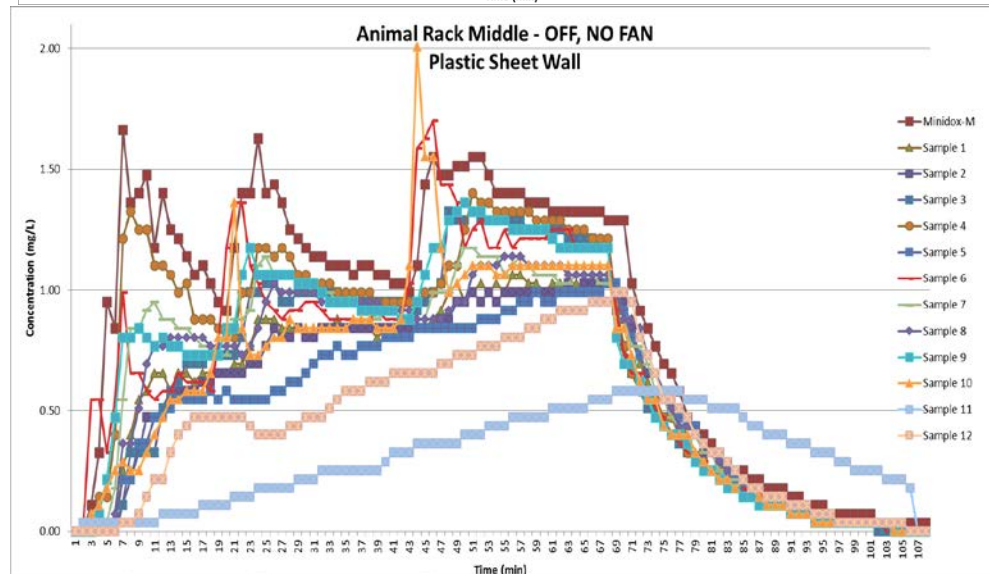
In **Configuration 8** an IVC Rack in the center of the room with the rack turned off, the Vornado 530W fan and plastic bisecting the room from front to back and ceiling to floor. The distribution of 11 readings closely follow each other reading. Sample 11 was inside the IVC cage and the rack was turned off, so gas slowly diffused into the cage.



Configuration 9 testing was done the same as configuration 8 with a smaller fan to test the effect of different fans. With this configuration distribution was good, but here was a noticeable lag from one side of the room to the other. Samples 3, 4, 6, 9 & 10 reached concentration minutes quicker than 1, 2, 4, 7, 8, 11 & 12. Samples 3, 4, 6, 9 & 10 were on the left side of the room (where the injection point was located) and samples 1, 2, 4, 7, 8, 11 & 12 were on the right side of the room.



Configuration 10 testing was done the same as configuration 8 with NO fan. In this configuration gas does eventually distribute throughout the space, but it takes time for this distribution to occur. Charge time for the room is approximately 15 minutes and gas concentration stabilized at minute 70. So gas distribution was achieved in 55 minutes with NO fan in this completely divided room.



Conclusions

Chlorine dioxide is a true gas at room temperatures. As such its distribution is excellent compared to vapor phase hydrogen peroxide, mists or fogs. As shown with the data charts, CD gas gets distribution with a single fan in empty rooms (configuration 1), equipment present (configuration 4) and with the plastic sheet (configuration 8). When the fan was reduced to a small compact muffin fan the distribution was still good in the empty room (configuration 2), the room with equipment (configuration 5) and with the plastic sheet (configuration 9). Even when NO fan was used there was adequate distribution in an empty room (configuration 3) and equipment in the room (configuration 6). With the plastic sheeting and no fan (configuration 10) the distribution was not adequate. ClorDiSys does recommend the use of fans to achieve the best distribution, since this is key for any decontamination to be successful.



Figure 2: IVC Center Room



Figure 3: Plastic Sheet



Figure 4: Plastic Sheet



Figure 5: Tubing Location



Figure 6: Tubing Location

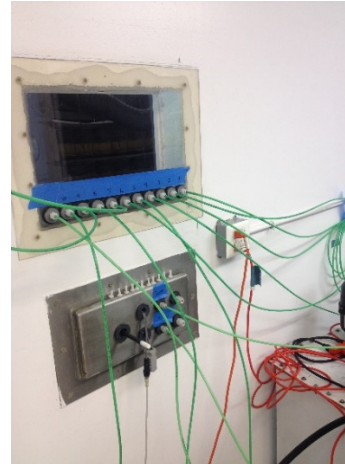


Figure 7: Tubing Location

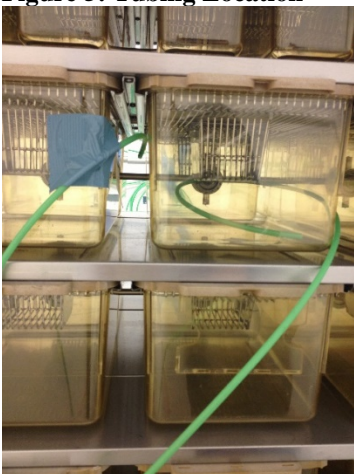


Figure 8: Tubing Location



Figure 9: Minidox-M / EMS