**LUNAR DUST GLOVEBOX OPERATION MANUAL**

**GLOVEBOX ASSEMBLY**

1. Drawings can be sent to researcher’s machine shop
2. Measure and cut the gasket so that there are 2 pieces of each lengths: 36.5 inches, 23.5 inches, 5.5 inches, and 4.5 inches
	1. Will have to glue pieces together to get the longer lengths
	2. The two longer lengths are for the side of the larger box seal, the smaller lengths are for the funnel enclosure seal
3. Peel adhesive backing off of the gasket and place
	1. The 23.5-inch-long pieces will be placed first, on the top shorter inner edges of the flange, fitting from inner corner to inner corner. The 36.5-inch-long pieces will be placed next on the top longer inner edges of the flange, fitting from outer previously placed gasket edge to outer previously placed gasket edge. All pieces of the same lengths should be place parallel to each other
	2. The 4.5 inch long pieces should be place on the sides of the top inner edges of the flange paralel to the larger box seal gasket, fitting from inner corner to inner corner. The 5.5 inch long pieces should be place next on the top inner edges of the flange, fitting from outer previously placed gasket edge to outer previously placed gasket edge. Again, all pieces of the same lengths should be place parallel to each other
4. Inserting the vacuum cylinder and female portions

**CPU MOUNT ASSEMBLY**

**Figure 1: CPU Fan Assembly Schematic**

1. Spray the suction cup cover, suction cup mount head, and fan mount head with Flex Seal Clear to minimize lunar dust simulant build up.
	1. Wear face and eye protection, protective gloves, and clothing.
	2. Cover the plastic suction cup part with aluminum foil.
	3. Surfaces being sprayed must be clean, dry, and free of grease, oil, and dirt.
	4. Shake well: Spray 1 foot from surface.
	5. Apply two coats.
	6. Each coat must be dry before applying additional coats, typically 24 – 48 hours.
2. Super glue the fan mount head to the back, center of the CPU fan.
3. Let cure for 24 hours.
4. Apply the suction cup to the desired position on the glovebox wall.
	1. Create a circular, decal sticker with a radius of 3 inch mm
	2. Using a sharpie, draw a dot on the sticker creating a datum point.
	3. Apply the decal sticker to the desired position on the outside of the glovebox wall.
	4. Align the suction cup on the inside of the glovebox wall with the decal sticker.
	5. Apply pressure on the suction cup to latch on the wall.
	6. Remove the decal sticker.
	7. If residue is present, apply isopropyl alcohol to a microfiber towel to remove excess.
5. Let the section cup seal with no applied pressure for 24 hours.
6. Align the suction cup mount head with the fan mount head holes.
7. Rotate the fan mount head – pivot joint prong to the desired angle.
8. Insert a M6 x 40mm socket head screw through all holes.
9. Secure the screw with a M6 x 1.0 nut with a wrench, until tight.
10. Insert the now combined CPU fan, fan mount head, and suction cup mount head into the suction cup ring.
11. Repeat steps 1-11 for each fan.

**CPU FAN WIRING ASSEMBLY**

**Figure 2: CPU Fan Schematic**

1. Confirm that the power control – controller is switched in the off position.
2. Run the power control- male through the glovebox wire hole.
3. Plug in the CPU fan wire – female to the power control – male.
4. Adjust slack in CPU fan wire – female and power control -male to desired position.
5. Apply vacuum seal tape to the power control-male to secure and seal the glovebox wire hole.
6. Plug in the power control outlet – male to the extension cord – female.
7. Plug in the extension cord – male to the US wall outlet.
8. Turn the fan on by adjusting the power control – controller knob to the desired speed.
9. Repeat steps 1-8 for each CPU fan.

**CPU FAN & MOUNT TROUBLE SHOOTING**

***Suction Cup***

If the suction cup begins to not secure to the wall, try these procedures:

1. **Clean the Suction Cup and Surface**
	1. Remove the suction cup from the surface.
	2. Clean both the suction cup and the surface where it will be reattached. Use warm water and mild soap to wash off dirt, oil, or debris from both.
	3. Dry both the suction cup and surface thoroughly with a lint-free cloth or paper towel.
	4. If necessary, use rubbing alcohol to wipe both surfaces to remove any lingering residue.
	5. Reattach the suction cup to the clean, smooth surface by pressing down firmly to create a better seal.

### **Moisten the Suction Cup**

### Gently dampen the suction cup with a small amount of water.

### Avoid soaking it; just lightly moisten the edge of the cup where it contacts the surface.

### Press the suction cup firmly against the surface to create a better seal. The moisture helps to create a stronger vacuum, especially on smooth surfaces.

### **Apply a Thin Layer of Petroleum Jelly or Oil**

### Apply a small amount of petroleum jelly (Vaseline) or a light oil (like baby oil or cooking oil) to the edge of the suction cup.

### Spread it evenly to create a very thin layer on the rubber.

### Attach the suction cup to the surface, pressing firmly. The lubrication helps improve the seal and can help the suction last longer.

### **Use a Vacuum Pump to Enhance the Seal**

### Use a small, hand-held vacuum pump (often used for suction cups and shower caddies).

### Attach the suction cup to the surface.

### Place the pump over the suction cup’s valve or opening (if it has one).

### Pump out the air to create a stronger vacuum and help the suction cup reattach more securely.

### Once the pump indicates that maximum vacuum pressure is reached, ensure the suction cup is securely affixed to the surface.

***Wiring***

1. **Check for Loose or Damaged Connections**
	1. **Unplug the extension cord** or device from the outlet and ensure everything is powered off for safety.
	2. Inspect both the plug (at the outlet side) and the device end of the extension cord for any visible signs of damage, such as frayed wires, exposed copper, or burn marks.
	3. If there are visible signs of damage or wear, **replace the extension cord** or wire, or repair the damaged section by cutting out the faulty area, stripping the wires, and reconnecting them properly using wire nuts or electrical tape (make sure the connections are secure and insulated).
	4. **Check the outlet** to ensure it's working by testing it with another device or using a circuit tester to verify that there’s power coming from the outlet.
2. **Use a Multimeter to Test Continuity**
	1. **Unplug the extension cord from the outlet and any device that may be attached to it. Ensure there is no power running through the wires.**
	2. **Set your multimeter to measure continuity (or resistance if your multimeter doesn't have a specific continuity setting).**
	3. **Touch the multimeter probes to the prongs of the plug at one end of the extension cord (for the live and neutral wires).**
	4. **If the multimeter beeps or shows a low resistance reading, the wire has continuity, meaning it is not broken. If there is no beep or a very high resistance reading, there’s a break or damage in the wire somewhere.**
	5. **Move along the wire to different sections, checking for any interruptions in the continuity. If the wire is damaged at a certain point, you'll need to repair or replace that section.**
	6. **If the wire shows continuity but the extension cord still doesn't work, check the outlet to ensure it’s providing power (using a voltage tester or another device).**

**OPENING GLOVEBOX TOP**

1. With all the proper PPE on, use a combination wrench to hold the nut in place with one hands, as you begin to loosen the bolt connected with a socket wrench to remove the polycarbonate top from the funnel enclosure. Repeat in a criss-cross manner for all bolts connected to the funnel enclosure. Be careful to account for all of the small washers in between
2. Next, remove the gasket piece that sits between the funnel stopper and the funnel opening
3. Next, take the previously baked simulant from the container it is in and pour it into the glovebox using the funnel opening. Be careful not to spill it
4. Next, place the barrier gasket piece back on the opening of the funnel hole
5. Next, place the funnel enclosure top back on top of the funnel enclosure
6. Next, place a washer direct in the center of a corner hole, followed by a bolt that goes through the center of the same washer and polycarbonate hole. Next place another washer around the bolt from the bottom side of flange, followed but a nut oriented the same way
7. Next, use a combination wrench to hold the nut in place with one hand, as you begin to tighten the bolt connected with a socket wrench to re-attach the polycarbonate top for the funnel enclosure. Repeat in a criss-cross manner for all bolts connected to the funnel enclosure

**CLEANING GLOVEBOX**

1. Fully saturate a microfiber cloth with isopropyl alcohol
2. Next, start to wipe the inside of the box, starting with the areas that are the most congested with simulant
3. Continue wiping until clean
4. Dispose of cloths

**GENERAL SAFETY**

* Transport the box with some type wheeled cart, wagon, or other transporting device
	+ Prevent injuries due to strain from the weight of the box
* Make sure to keep all PPE on from the time that simulant is introduced to the room you are in to the time that the simulant is completely disposed of.
	+ Prevent damage to airways and skin due to the size and abrasiveness of the particles

**EXPERIMENTAL PROCEDURE**

1. Ensure area preparation
	1. Have all necessary materials including PPE, camera, UV light, box equipment, fans, funnel, cleaning supplies, simulant, microspheres, tape, sharpies, dry erase markers, stopwatch, scissors, camera, dino-lite microscope, and utensils for notes
	2. Make sure the fans, light, and other equipment work properly first to prevent hazards
2. Enter and inspect the experiment area
	1. Check that area is clear of spills, hazards, or individuals not associated with the project
3. Put on PPE
	1. Make sure all members have long pants, closed toes shoes, lab coats, and safety goggles
	2. Ensure N95 masks are fitted to form the face
	3. Locate eye wash station and safety shower in the room and ensure they work
4. Insert simulant
	1. Please see procedure previously detailed.
5. Adjust suction cup fan mounts in desired positions
	1. Use a measuring system and marker to indicate the placement of the suction sups during each run.
6. Adjust the angle of the fans to desired position using built-in protraction
7. Test fans once in desired position
	1. Plug in fans and ensure the wire is out of the way and not a tripping hazard
	2. Turn fans on for 10 seconds by pushing “on” button to ensure wiring was not compromised
8. Seal the fan wire exit points by apply putty between the wire and inner diameter of the opening
9. Use a dry erase market to mark the outside of the box where tape will go
10. Tape (13x20 mm)
	1. Place 6 pieces of labeled double-sided tape inside the front wall with gloves on
		1. Careful not to smudge tape
	2. Place 9 pieces of tape in a 3x3 array on each inside side of the glovebox
	3. Place 15 pieces of tape in a 3x5 array on the back inside of the glovebox
11. Close glovebox
12. Check ventilation
	1. Turn on fume hood
	2. Verify the room’s ventilation system is operational before starting testing
	3. Ensure fume hood is active by putting a paper towel inside
13. Gather all materials inside the room
	1. Bring in all necessary materials and equipment to the experimental area if they are not already there (easy access during testing)
	2. Use carts or secure carriers for heavy/fragile/sensitive objects and materials (avoid strain, spills or drops).
14. Turn on UV lights
	1. Ensure the lights are functioning properly and there are no unwanted reflections
	2. Avoid looking directly at UV lights
15. Open the funnel top and insert simulant mixture
	1. Unplug the funnel hole on the top of the glovebox
	2. Carefully pour simulant into the funnel (correct amount will be in petri dish since it was weighed prior to baking)
		1. Be mindful of how the micro particles will directly affect environment upon unsealing
		2. Handle carefully to prevent spills
		3. Keep hands steady
		4. Insert slowly to prevent dust clouds or clumping, masks will protect from inhalation
16. Allow dust to settle
	1. Allow a brief period for any dust generated during the simulant insertion to settle before turning on any fans; helps ensure a controlled environment
	2. Stand back from funnel area to decrease inhalation risks and allow ventilation systems to clear area
17. Take initial photos
	1. Take photos of each piece of tape on the front of the box once dust has settled
		1. Use Manual mode, no auto focus
		2. Wide aperture: 56 if zoomed in and 4 if zoomed out
		3. Shutter speed she be the only variable, record speed
		4. Use long exposure because there is so little light
18. Ensure label is in view in each photo
19. Turn on fans by turning the knob on the power control to the desired speed.
	1. These fans (inside of the glovebox) will move and loft the lunar dust simulant
	2. Check for any be aware of any noticed leaks when the fans begin operating.
	3. Take photos of each piece of tape within the first 15 seconds of turning the fans on
20. Observe the experiment and take photos
	1. Take photos of each piece of the tape on the front of the box at T = 1 minute
	2. Take photos of each piece of the tape on the front of the box at T = 2 minutes
	3. Take photos of each piece of the tape on the front of the box at T = 3 minutes
	4. Take photos of each piece of the tape on the front of the box at T = 4 minutes
	5. Take photos of each piece of the tape on the front of the box at T = 5 minutes
	6. Record any necessary observations, paying attention to the simulant’s movement, dust dispersion, or other critical data.
21. Turn off fans after 5 minutes and wait for dust to settle
	1. After the observation period, turn off the fans to stop the airflow.
	2. Allow the dust or simulant particles to settle (ensuring a stable environment before disassembling or moving any components)
	3. Take photos of each piece of tape on the front once dust has settled
22. Take microscope photos
	1. Use Dino-Lite USB Digital Microscope to take microscopic photos of each piece of tape at the front of the box
	2. Ensure tape labels are logged to corresponding photos
23. Turn glovebox to side
	1. Carefully move glovebox inside fumehood so the side is accessible
	2. Take camera and microscopic photos
24. Turn glovebox to back
	1. Carefully move glovebox inside fumehood so the back is accessible
	2. Take camera and microscopic photos
25. Turn glovebox to other side
	1. Carefully move glovebox inside fumehood so the other side is accessible
	2. Take camera and microscopic photos
26. Remove camera and computer equipment from testing area
27. Turn off UV lights and remove from testing area
28. Open the glovebox
29. Wet the inside of the glovebox
	1. Immediately wet the inside to minimize aerosol hazard from the simulant
	2. Wipe down all the inside surfaces using isopropyl alcohol wipes
30. Remove the fans
	1. Slowly and carefully remove the fans from the setup
	2. Handle fans gently to prevent scattering any remaining particles
31. Clean the fans with isopropyl alcohol
	1. Using isopropyl alcohol and a clean cloth or wipe, thoroughly clean each fan blade and part to remove any remaining lunar dust simulant particles
	2. Avoid skin contact
32. Discard used wipes safely in a marked flammable hazard trash bin
33. Wipe down the box with isopropyl wipes
	1. Use isopropyl wipes to clean the inner walls of glovebox
	2. Wipe up all remaining wet simulant
	3. Avoid skin contact
34. Discard used wipes safely in a marked flammable hazard trash bin
35. Turn off fumehood and clean room
	1. Clean the room of any debris and gather all materials
36. Remove PPE
	1. Take off all personal protective equipment carefully, dispose or store equipment as necessary
	2. Follow proper procedures for removing PPE to avoid accidental contamination
	3. Wash hands thoroughly after removing gloves
37. Exit the room

**SIMULANT BAKING PROCEDURE**

1. Gather materials (simulant, scale, glass petri dishes, gloves, N95 masks, timer, writing materials)
2. Enter room 124 HPMI
3. Check for ventilation
4. Turn ovens on and set to 200 degrees C
5. Open the bag of simulant and put petri dish on scale
6. Scoop desired amount into glass petri dish
7. Place glass petri dish with simulant into the ovens
8. Set time for 12 hours
9. After 12 hours, remove simulant and store in a dry place
10. Turn oven off

**VACUUM TESTING PROCDURE**

1. Gather materials (soap, hose, nozzle, water cup, glovebox, dry erase markers)
2. Add a few drops of soap to a half cup cup of water and stir
3. Apply soapy water generously at all the edges and corners of the glovebox
4. Attach hose nozzle to glovebox hole and ensure secure
5. Turn air on and look for soapy bubbles
6. If there are any soapy bubbles, circle bubbles in dry erase markers

**COMPUTATIONAL FLUID DYNAMICS**

Important simplifications / Assumptions

* Steady state flow
* Multiphase flow (solid and gas mixture)
* 10,000 particles of simulant settled on the bottom of glovebox floor
* Uniformly distributed lunar simulant diameters between 0.04-35 microns
* Isothermal Heat Transfer Model: 25°C
* Student Edition Ansys
* Fans modeled as velocity inlets
* Fan angles are only in two directions
* Meshing of 5.4 million elements
* 500 iterations for solver
1. Download and install CFD software such as Ansys
2. Import CAD into project
3. Edit geometry until volume inside glove box is left
4. Set enclosure around geometry. This will create an enclosure geometry that sketches/edits can be made too. The previous geometry should be “suppressed for physics” and hidden so edits can be made to the enclosure geometry
5. Draw inlets at desired positions on enclosure geometry
6. Mesh geometry
7. Specify the boundary condition at each of the inlets drawn previously to desired velocity settings. To include fan angles at each inlet, specify the components of the velocity
8. Define a new material for the lunar simulant to be used, and include it in the fluid and particle model definition under the “default domain”
9. Define a wall boundary condition on the floor of the glove box. Define the particle behavior at the floor, making it evenly equally spaced with uniform diameters
10. Enable gravity under fluid and particle definitions for both air and lunar simulant
11. In solver control, increase the max number of iterations to 500
12. Run the solver. Analyze the residual plots to see if the solution is converging. This generally means that the variables settle at a certain value or continuously get smaller. If solution does not converge or generally settle at a certain residual value, increase the mesh and run the solver again
13. Analyze velocity fields, simulant mass concentrations, and streamlines for dead zones/low velocity regions