



ATAMI Standard Operating Procedure

MAML (Metals Additive Manufacturing Lab)

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Revision	Date	Description/Change	Curator
0	3/25/2019	New document	Randy Greb
1	5/6/2019	Added downdraft table procedures. Added safety cautions regarding using carts. Updated info on SDS sheets.	Randy Greb
2	6/26/2019	Typo updates, room access and training updates	Randy Greb



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Scope:

This procedure covers safety, gowning and basic operating procedures required for entrance into the MAML lab room. These procedures will help ensure the following:

1. Nobody should ever inhale metal powder.
2. Metal powder never leaves the room in a way that can contaminate other spaces.
3. Safety awareness is emphasized to avoid injury or exposure to unhealthy substances or conditions.

All operations and maintenance procedures for the equipment in the lab are covered in equipment specific SOP' and SMP's.

Lab cleaning and support equipment (vacuums, bins, supplies) maintenance procedures are included in the MAML lab SMP (standard maintenance procedures).

System Specifications:

The MAML lab room contains 3D metal printers, a glovebox, high temp furnaces, a downdraft table and room, support equipment and hazardous materials and supplies. Specifications for each of the 3D printers are documented in their associated SOP's.

Safety

General

The MAML lab has significant hazards - explosive powders, toxic powders, laser energies, mechanical energies, inert gasses and noise. **All safety protocols must be strictly followed. Failure to follow safety protocols will results in loss of room access.**

Because of the nature of the materials processed in this lab, safety protocols are critical to prevent toxic exposure to metal powders and contamination of spaces outside of the labs with metal particles carried on clothes. Metal powders can also be explosive if proper procedures are not used, resulting in severe risk of injury or death.

The following situations are not allowed in the MAML lab:

1. Open powder containers, with the following exceptions:
 - a. Processing in the downdraft table.
 - b. During service of the 3D equipment by trained personnel, only.
2. Handling of powder without correct PPE.



3. Violating any safety interlocks on the 3D printing equipment.

The **stainless steel carts must be used whenever a part or powder is moved** in out of a printer, furnace or the downdraft table.

PPE Required

PPE required anytime you are working in the room (touching equipment, cleaning,...):

1. Safety glasses (as is standard in all ATAMI labs).
2. Booties
3. 9.5” nitrile gloves

A lab coat is recommended, but not required. Contact ATAMI staff to acquire a lab coat.

PPE required for any activity that involves handling powder. Examples of activities that involve handling powder include loading new powder, cleaning of the 3D printing systems, removing build parts and cleaning build parts in the downdraft table.. This PPE is also required at all times in the downdraft room.

1. Full bunnysuit
2. 12” outer nitrile gloves over 9.5” inner nitrile gloves
3. PAPR respirator with P100 rated cartridge (such as 3M Versaflo, Full Face Scot,...)

All PAPR users must go through the following training and certification process shown below in the training section:

Hazardous Energies

Electrical

There is potential for electrical hazard during equipment maintenance. All maintenance safety protocols must be followed to avoid a hazardous electrical situation.

Mechanical

The following pinch hazards are present in the lab and all lab users should use caution when handling or operating associated equipment:

1. Heavy build plates for Prox300 printer.
2. Moving parts in the 3D printing equipment. Risk of severe injury is present during maintenance.

Stored/Potential

Compressed gases are present in bottles and equipment. All OSU-standard gas hazard and bottle handling procedures must be followed to prevent injury from exhausting gases.

The tamping plate in the ProX300 presents risk of severe injury if CDA and “drop-locks” fail. Refer to equipment specific procedures before exposing body parts to that part.

Thermal



The annealing ovens can reach high temperatures and operation protocols must be strictly followed to avoid burns.

Risk of dust explosion requires the following protocols:

1. 120V outlets cannot be used except under strict control of qualified lab specialists to avoid sparks.
2. All gowning, cleaning and operation protocols must be strictly followed to avoid build-up of flammable dust.
3. Only trained users are allowed to use the annealing furnaces to avoid risk of conditions that could lead to combustion of dust.

Materials/Consumables Hazards

Inhalation of metal dusts is dangerous. Read the SDS for the dust before handling.

Please see the OSU inventory system for a list of chemicals used in the MAML lab - <https://ehs-ers.tss.oregonstate.edu/ehsa/inventory/chemicalinventory/chemicalinventorylist>

If you are using a powder or chemical and are unsure if it is approved for use in the MAML lab, contact ATAMI staff to determine if it is approved. If not, ATAMI staff will assist you with the approval.

Interlocks

There are numerous interlocks on the 3D printers to prevent to protect against serious risk of mechanical or laser caused injury. **Interlocks can only be bypassed by qualified service personnel from the equipment supplier.** If you defeat any interlocks you will be asked to leave the lab until a follow up investigation is completed.

Training Requirements

- A. For entrance in to the lab:
 - a. Pass all ATAMI required safety courses
 - b. Finish lab tour with qualified ATAMI trainer.
 - c. Complete all hands on training for the room and get signed off by trainer.
 - d. Verify access to this document for reference.
- B. [PAPR Respirator training](#):
 - a. Fill out the following questionnaire and send it in confidential mail to OSU occupational health (<https://occupationalhealth.oregonstate.edu/contact-ohs>)
https://ehs.oregonstate.edu/sites/ehs.oregonstate.edu/files/pdf/occsafety/respirator_user_medical_evaluation_questionnairefillable.pdf
 - b. Complete respirator fit test and training.



- c. PAPR certification by EHS (contact Nick Wannemacher to schedule EHS certification)
- d. Complete ATAMI-MAML lab specific training.
- C. Finish the lab training checklist and signoff procedure.
- D. For use of the 3D printers, downdraft table or furnaces:
 - a. Complete tool specific training
 - b. Read and reference tool specific SOP's
 - c. Complete tool specific training checklists and signoff.
- E. Annual re-certification with EHS for PAPR respirator use. This will be tracked by ATAMI lab.

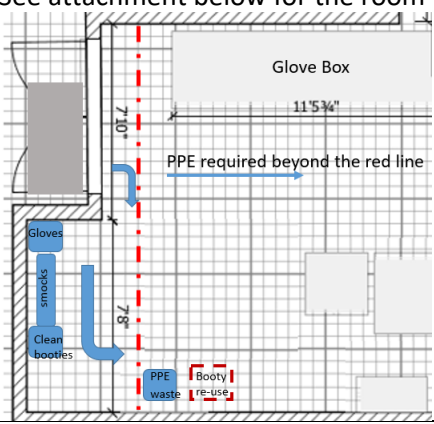
Guest Access


- A. Guests may enter the lab if accompanied by a qualified lab specialist or trained user at all times. Guests must follow the same gowning and safety procedures as lab users.
- B. There may be specific exceptions for construction activities, supplier equipment repairs or specific tours.

Procedures

Entrance and Gowning procedure for lab workers:

All procedures below must be completed in the specified order to avoid metal powder contamination.

Step	Action	Notes
1	Always wear approved safety glasses before entering the lab.	Gowning sequence must be followed in the order listed in this procedure.
2	Do not cross the line labelled “PPE required beyond this point” until donning correct PPE as described in the next steps.	
3	After entering the door turn right and put on a pair of 9.5” gloves from the rack.	See attachment below for the room flow. 
4	If you are using a lab coat, put it on now. Lab coats are optional.	If you do not have a designated lab coat, then use one of the guest lab coats..

5	Get booties from the bin and cover your shoes while sitting on the bench.	<p>Try to keep shoes on the left side of the line, and booties on the right side, as shown here:</p> 
6	At that point you can cross the PPE line and enter the room.	

Exit and De-gowning for lab workers:

Step	Action	Notes
1	<p>Walk up to the PPE line and remove one bootie at a time and put them in the used bootie bins.</p> <p>Try to keep un-covered shoes on the non-PPE side of the line, and booties on the PPE side.</p>	If you are planning on returning in a short time to the lab, you can place your booties in the area on the floor labelled “bootie re-use”. You can then re-use those booties when you return.
2	Remove your gloves and place them in the labelled garbage bin.	Be sure to roll them off carefully so that you do not contaminate your lab coat with metal powder.
3	Hang up the lab coat on the assigned hangars.	Guest hangars are assigned to positions 1-5. Frequent lab users will have assigned hangars beyond that.
4	Exit the room.	Crossing the sticky pad on the way out will provide some reduction in particles on the room.
5	Thoroughly wash your hands in the restroom before moving to other activities.	

Donning long gloves, Tyvek suit and PAPR respirator

Step	Action	Notes
1	Go to the Tyvek hangar rack.	<u>Steps for gowning must be followed in the order listed here to avoid cross-contamination.</u>
2	Hang your lab coat on an open hangar to the left.	



3	Carefully remove your booties and place them on the rack to the left.	
4	Put 12.5" nitrile gloves on, <u>over</u> your room glove.	These gloves have longer sleeves for use with the Tyvek bunnysuit. If your 9.5" room gloves are dirty, dispose of them in the labeled garbage container, replace them, and then put on the 12.5" gloves.
5	Put your bunny suit on.	All people certified to use full PPE will have a dedicated bunnysuit and hangar position. Place the elastic band of the sleeve over you glove. <u>Avoid contaminating the inside of the bunnysuit.</u>
6	Don the PAPR respirator.	All PAPR respirator users are required to complete EHS specific training and certification. If you are not certified and trained to use a PAPR respirator, you may not use them.

Removing long gloves, Tyvek suit and PAPR respirator






Step	Action	Notes
1	Remove the PAPR respirator per the procedure below .	
2	Carefully remove the bunnysuit and return it to its designated hangar location.	If the bunnysuit is contaminated with powder, you will need to very carefully roll it up to and place it in the bin with dirty booties. Do not return dirty, contaminated Tyvek bunny suits to the hangar.
3	Remove your 12.5" nitrile gloves.	You should have the standard, 9.5" gloves underneath.
4	Put your lab coat back on.	
5	Put your booties back on.	

Putting on the 3M Versaflo PAPR respirators:





Do this after you are dressed in a clean Tyvek suit.

Step	Action	Notes
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1	Get a battery from the battery table and verify charge.	<p>Test the battery charge by pressing the test button on the bottom of the battery.</p> 
2	Connect the battery to one of the filter/belt assemblies	
3	<p>Verify that a filter is installed.</p> 	<p><u>Only qualified lab users are allowed to change filters. If you suspect an issue with a filter, contact one of the people listed above under training requirements.</u></p>
4	<p>Test the airflow per 3M procedure by placing the floating ball unit and verifying that it is at the specified mark, per the reference attached to the tube.</p>	
5	<p>Check that the in-use alarms are working by placing a hand over the outlet of the airflow unit.</p> <p>The alarm should sound and the LED should flash after about 20-30 seconds.</p> <p>If it doesn't, do not use this unit and contact a qualified lab user.</p>	
6	Place the correct end of the connection into the outlet of the filter pack.	
7	<p>Get your assigned helmet from the helmet cabinet.</p> <p>Ensure that it is clean and not contaminated by powder.</p>	<p>If the outside surfaces are contaminated by powder, they can be wiped down with the lab wipes and water.</p>



		If the cloth filter shield or the inside surface is contaminated with powder, contact a qualified MAML user for help.
8	Switch the air supply back on and let it run for 5-10 seconds to clear any particles from the tube.	
9	Connect the tube to the helmet as shown here.	
10	Place the helmet on your head, <u>over the Tyvek suit hood</u> , with the visor raised and ensure a comfortable fit.	
11	Put the powered turbo belt around the waist, assuring a comfortable fit.	
12	Lower the visor to the down position by pulling on the loop until the cloth face shield is under the chin and is secure around the chin and face. This will prevent toxic dust from entering your breathing area, so be sure to fit it properly.	 

Taking off the 3M Versaflo PAPR respirators:





Step	Action	Notes
1	Remove your used 12.5" gloves and put on clean fresh gloves from the supply.	<u>Do this every time you remove the helmet.</u> Fresh gloves will help prevent contamination of the helmet.
2	Raise the visor and turn off the fan.	
3	Very carefully remove the helmet and disconnect the breathing tube. Turn off the power pack and place the helmet in the assigned location in the helmet cabinet.	<u>Ensure that you DO NOT CONTAMINATE the inside of the helmet or the cloth shield.</u>
4	Carefully remove the fan unit and place it in the fan unit part of the cabinet.	
5	Remove the battery and place in the battery charger.	

How to Use the Downdraft Table

Step	Action	Notes
1	Ensure that you always pay attention to the safety precautions here when you use the downdraft table.	<ul style="list-style-type: none"> • Build plates can be heavy. Use caution to avoid pinching when handling heavy objects. • Always use full PPE – Tyvek suit and PAPR when cleaning parts in the table. • Use caution when blowing metal dust to ensure it is directed down and to the back of the table. High pressure blowing can cause particles to move beyond the confinement of the downdraft table. • Always ensure only clean glove touch the surface of the RUWAC vacuum cleaner when you turn it on and off.
2	Only move parts from the printer to the downdraft table using the stainless steel carts. DO NOT CARRY PARTS BY HAND TO TABLE SURFACES OR ACROSS THE ROOM.	Un-cleaned parts should only contact the printer, the stainless steel carts and the downdraft table.



<p>3</p>	<p>Open the water valve to the table.</p>	
<p>4</p>	<p>Turn on the downdraft table.</p>	
<p>5</p>	<p>Carefully clean the part.</p>	<p>Ensure that dust does not leave the downdraft table work area.</p>
<p>6</p>	<p>After cleaning, wipe down all surfaces with towels, water and IPA.</p> <p>Also, spray down the build table yellow work surface and the back wall with the sprayer, and then wipe down with the towel.</p>	<p>Surfaces include:</p> <ul style="list-style-type: none"> Build plates Cart surfaces All table surfaces All tools.
<p>7</p>	<p>Dispose of all towels and extra metal parts in a ziplock bag. Carefully zip it so that outgoing air will blow into the downdraft table area.</p>	
<p>8</p>	<p>After the table, cart and parts have been cleaned, turn off the table and close the water valve.</p>	

Basic Troubleshooting

If you hear the O2 sensor alarming:



Step	If	Then	Notes
1	You hear the O2 alarm.	<ol style="list-style-type: none"> Exit the room, immediately. Call emergency contacts – see list posted near the door. Barricade the entrance so nobody can enter. Keep the doors closed. <u>Do not re-enter the room</u>, even if the alarm has stopped. Wait until emergency contact arrives to assess the situation. Carefully remove PPE and store in a black plastic bag. 	Barricades will be placed near the door in a labelled location.

If you see any clouds of dust or piles of dust of unknown origin:

Step	If	Then	Notes
1	You see any clouds of dust in the room.	<ol style="list-style-type: none"> Exit the room, immediately and <u>close the doors behind you</u>. Call emergency contacts – see list posted near the door. Barricade the entrance so nobody can enter. Close the doors to contain any potential for explosion <u>Do not re-enter the room</u>. Wait until emergency contact arrives to assess the situation. Carefully remove PPE and store in a black plastic bag. 	Barricades will be placed near the door in a labelled location.
2	If you see a pile of dust powder of unknown origin.	<ol style="list-style-type: none"> Assume it is hazardous and leave it in place. Exit the room and carefully remove PPE per standard procedures. Barricade the entrance so nobody can enter. Call the MAML lab emergency contact for a cleanup. The cleanup will happen with the RUWAC, wet vacuum. 	

Attachments

3M Videos for how to use Versaflo helmets

[Using the battery and filter unit.](#)

[Using the headtop.](#)

