ATAMI Standard Operating Procedure

MAML (Metals Additive Manufacturing Lab)

Last saved by Randy Greb on 6/26/2019 3:22 PM

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
3	2/18/2020	Updated EHS contact name	Randy Greb
4	1/1/2021	Updated Training links to make this easier to read.	Randy Greb
5	11/30/2021	Updated gowning procedures, updated room entry procedures, COVID specific notes, downdraft table procedure changes	Randy Greb

Contents

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. Eliminate hazardous exposure to powder through inhalation or skin contact.
2. Metal powder never leaves the room in a way that can contaminate other spaces.
3. Emphasize safety awareness 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 safety interlocks on the 3D printing equipment, unless using a documented service procedure, pre-approved by the manufacturer.

Use the stainless steel carts whenever moving a part or powder in out of a printer, furnace or the downdraft table.

Always wipe down the carts after use and return them to their standard locations so that the next person can use them.

PPE Required

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

1. Safety glasses (as is standard in all ATAMI labs) if work on any tools is planned.
    a. While masks are required for COVID-19 containment, it is OK to remove glasses if they fog up and you are in the room observing activities.
    b. If you are working on any of the process tools (printers, vacuums, furnaces,..) or conducting activities such as cleaning, you should wear goggles. Cleaning with Windex or de-fogger can help reduce fogging.
2. 9.5" nitrile gloves when contacting any surfaces in the lab.

Lab coats 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 Tyvek 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. Avoid using 120V outlets to reduce risk of sparks.
2. Follow all gowning, cleaning and operation protocols to avoid build-up of flammable dust.
3. Formal training and process approvals are required before the use of the annealing furnaces to reduce fire risk.

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 banned from the lab until a follow up investigation is completed.

Training Requirements

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.

PAPR Respirator training:

e. OSU PAPR page is here for reference: https://ehs.oregonstate.edu/respiratory-protection-program
f. 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

g. Complete respirator fit test and training.

h. PAPR certification by EHS (contact Kent Lanning , Kent.Lanning@oregonstate.edu, to schedule EHS certification)

i. Complete ATAMI-MAML lab specific training.

B. Finish the lab training checklist and signoff procedure.

C. 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.

D. Annual re-certification with EHS for PAPR respirator use. This will be tracked by ATAMI lab.

Guest Access

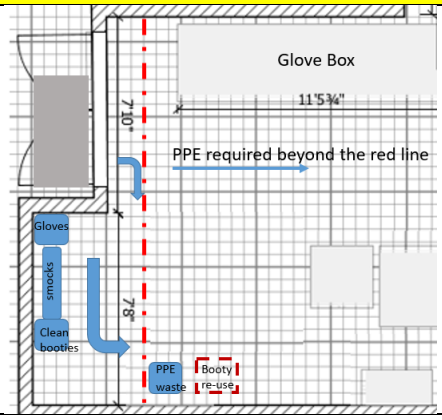
A. Guests may enter the lab if accompanied by a qualified lab specialist or trained user at all times. Guests must follow the same gowning and safety procedures as lab users.

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	If you will be working on tools, don safety glasses, gloves and lab coat as necessary before crossing the PPE line:	

(back to contents)

Donning long gloves, Tyvek suit and PAPR respirator

Step	Action	Notes
1	Go to the Tyvek hangar rack.	**Steps for gowning must be followed in the order listed here to avoid cross-contamination.**
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, over 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. **Carefully handle the bunnysuit to avoid contaminating the inside surfaces.**
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.

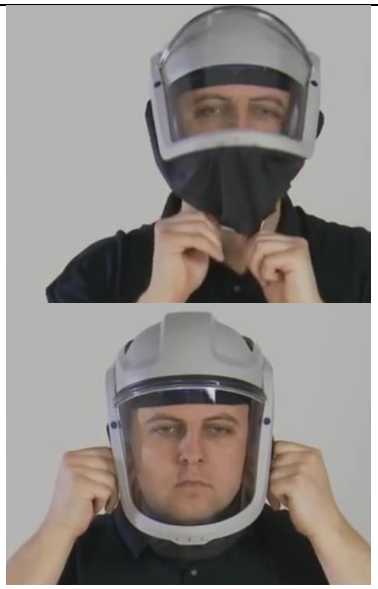
Removing long gloves, Tyvek suit and PAPR respirator

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 heavily contaminated with powder, carefully roll it up to and place it in the bin with dirty booties. **Do not return heavily 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.	

Putting on the 3M Versaflo PAPR respirators:

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

Step	Action	Notes
1	Get a battery from the battery table and verify charge.	Test the battery charge by pressing the test button on the bottom of the battery. 
2	Connect the battery to one of the filter/belt assemblies	
3	Verify that a filter is installed. 	**<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>**
4	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.	
5	Check that the in-use alarms are working by placing a hand over the outlet of the airflow unit. The alarm should sound and the LED should flash after about 20-30 seconds. If it doesn't, do not use this unit and contact a qualified lab user.	
6	Place the correct end of the connection into the outlet of the filter pack.	

7	Get your assigned helmet from the helmet cabinet. Ensure that it is clean and not contaminated by powder.	If the outside surfaces are contaminated by powder, they can be wiped down with the lab wipes and water. 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.	

(back to contents)

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.	**Do this every time you remove the helmet.** 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.	**Ensure that you DO NOT CONTAMINATE the inside of the helmet or the cloth shield.**
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.	• 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. • Clean parts as much as possible with the RUWAC vacuum cleaner • Use caution when blowing metal dust. Direct it down and to the back of the table. High pressure blowing can cause particles to move beyond the confinement of the downdraft table.
2	Clean all parts as much as possible with the RUWAC vacuum cleaner before cleaning in the downdraft table.	• The downdraft table is there to prevent exposure to powder. Do not use it as a powder collector.
3	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.

(back to contents)

4	Open the water valve to the table.	
5	Turn on the downdraft table.	
6	Carefully clean the part.	Ensure that dust does not leave the downdraft table work area.
7	After cleaning, wipe down all surfaces with towels, water and IPA.	Surfaces include: Build plates Cart surfaces All table surfaces All tools.
8	Dispose of all towels and extra metal parts in a ziplock back. Carefully zip it so that outgoing air will blow into the downdraft table area.	
9	After cleaning the table, cart and parts, turn off the table and close the water valve.	The downdraft table is not a storage location. If leaving parts on the surface for follow up work, they label them with your name, date and contact information.

Basic Troubleshooting

If you hear the O2 sensor alarming:

Step	If	Then	Notes
1	You hear the O2 alarm.	1. Exit the room, immediately. 2. Call emergency contacts – see list posted near the door. 3. Barricade the entrance so nobody can enter. 4. Keep the doors closed. 5. **Do not re-enter the room**, even if the alarm has stopped. Wait until emergency contact arrives to assess the situation. 6. 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 large, heavy clouds of dust in the room.	1. Exit the room, immediately and close the doors behind you. 2. Call emergency contacts – see list posted near the door. 3. Barricade the entrance so nobody can enter. 4. Close the doors to contain any potential for explosion 5. **Do not re-enter the room**. Wait until emergency contact arrives to assess the situation. 6. 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.	1. Assume it is hazardous and leave it in place. 2. Exit the room and carefully remove PPE per standard procedures. 3. Barricade the entrance so nobody can enter. 4. Call the MAML lab emergency contact for a cleanup. 5. The cleanup will happen with the RUWAC, wet vacuum.	

Attachments

3M Videos for how to use Versaflo helmets