1.0 PURPOSE:

This machine uses Selective Laser Melting (SLM) to create components made of metal from metal powder. 3D CAD data is used as a blue print for the component.

2.0 SCOPE:

This SOP will outline the necessary steps for operating this machine, as well as describe the required safety measures that need to be taken. Supervisors and the operators/technicians of this machine are required to know this SOP, in order to understand the safe and efficient operation of the machine. It is assumed that the MTT SLM125 is already properly installed and is assembled in its required conditions.

3.0 RESPONSIBILITIES:

- EVERYONE who uses the MTT SLM125 HAS TO FOLLOW all SOPs related to the MTT SLM125 (Principal Investigators, Project Managers, Technicians, Students)
- ONLY INDIVIDUALS WHO ARE TRAINED BY MTT (operation, maintenance, cleaning) may OPERATE THE MACHINE, unless accompanied by a fully trained individual
- ONLY AUTHORIZED KEY HOLDERS ARE ALLOWED ENTRY INTO THE ROOM.
    - Authorized personnel are NOT PERMITTED to allow entry to NON SUPERVISED UNAUTHORIZED PERSONNEL
- The operator/technician is FULLY RESPONSIBLE for following SAFETY & OPERATIONAL PROTOCOL, as well as reporting the work and any issues
- The REQUIRED safety courses to be taken include:
    - Laser
    - X-Ray
    - Radiation
    - Biohazard
    - WHIMIS
    - General lab safety
- UWO Health and Safety Website:
    - http://www.uwo.ca/humanresources/facultystaff/h_and_s/h_and_s_index.htm
- The individual must have taken these safety courses AND MTT training BEFORE operating this machine.
- SAFETY features MUST NOT be tampered with – all safety features must be in proper working order
- Individuals must receive specific on the job training for specific projects
- ALL MAINTENANCE will be done by MTT TECHNICIANS ONLY.
- Consult the Project Manager if there are any specific questions

4.0 DEFINITIONS:

- *LASER:* Light Amplification by Stimulated Emission of Radiation. A device that stimulates electronic/molecular transitions to lower energy levels, to emit a directional beam of light. The spectrum of electromagnetic radiation ranges from UV to IR.
- *CLASS 4 LASER:* Can burn skin & cause permanent eye damage, and ignite combustible materials.
- *PLC:* Programmable Logic Controller
- *User Access modes:*
  - *Level 1:* Allows for minimal user intervention, intended for operators on a daily basis
  - *Level 2:* Enables all operational functions required to run the machine, a supervisor level
  - *Level 3:* For forcing drives and valves, a maintenance only level
- *Substrate Thickness:* Thickness of plate bolted to the table

5.0 REFERENCES:

- Operating and Maintenance Manual: MTT SLM125

6.0 SAFETY

6.1 Protective Clothing

6.1.1 Tightly sealed goggles
6.1.2 P2 & P3 (R95-100 & P95-100) grade Respiratory Masks
6.1.3 Anti-Static clothing & footwear
6.1.4 Nitrile, Butyl or Fluorocarbon Rubber gloves

6.2 Metal Powders

- Users of the metal powder MUST read the appropriate MSDS for specific safety instructions.
- AVOID formation of dust
- KEEP AWAY from ignition sources
- KEEP metal powders AWAY from INCOMPATIABLE materials
- Store in a cool, dry place.
- Use a CLASS D FIRE EXTINGUISHER for SMALL, CONTAINABLE metal powder fires

6.2.1 Titanium Alloy ($TiAl_6V_4$)

- LARGE, BULK AMOUNTS are HIGHLY reactive with WATER
- INCOMPATIBLE with alcohols, oxidizing materials, aqueous acids & bases, halogenated compounds

6.2.2 Aluminum Alloy ($AlSi_{12}$)

- HIGHLY reactive with WATER – emits EXTREMLY flammable gasses
- VIOLENT REACTIONS with strong alkalis and oxidizing agents
- INCOMPATIBLE with alcohols, amines, aqueous acids
- AVOID electrostatic charges during handling

6.2.3 Cobalt Chrome (CoCr)

6.2.4 Tool Steel

6.2.5 Stainless Steel Powder

- See MSDS for specific safety information

6.3 Lasers

- CLASS 1 LASER equipment during normal operation
- CLASS 4 LASER when the laser cover is open during operation
  - Lock all doors, must have Laser Danger Sign stating “Class 4 Laser in Operation. No Admittance”
- Laser safety training REQUIRED before training and use of machine
- MTT SLM Laser Safety Classification Standard:
  - DIN EN 60825-1, edition:2001-11, Safety of Laser Equipment – Part 1: Equipment Classification, Requirements and User’s Guide (IEC 60825-1:1993+A2: 2001).

6.4 Mobile/Cell Phones

- MOBILE/CELL phone use PROHIBITED.
- SWITCH off all phones before entering the room
- DO NOT operate any equipment that emits HIGH-FREQUENCY RADIATION.

7.0 BASIC PROCEDURES:

7.1 Switching On

7.1.1 Plug the Red 16/3ph/N/E plug into a power supply, switch on.
7.1.2 Connect Argon cylinder to main regulator. Turn on supply.
7.1.3 Switch main isolator switch to “ON” or “1”.

7.2 Metal Powder Preparatory Operations

7.2.1. Measure and record thickness of substrate plate for reference
7.2.2. Cleaning must take place after every build
7.2.2.1. Remove powder cassette by unscrewing two knobs on each side
7.2.2.2. Remove top of powder cassette, fill it with metal powder in an Argon glove box with the proper safety equipment on, OR – remove lid, use a KF40 lid adapter inside the Argon glove box
7.2.2.3. Ensure the powder Overflow bottle is fitted correctly

9.0 OPERATOR LEVEL 1 PROCEDURES

9.1 Select **Log In/Out**
9.2 Select **Press Here to Log In** to input 6-digit code. User level will be highlighted yellow. A new menu screen appears.
9.3 Select **Open Door** on Door control page.
9.4 Select **DOOR INTERLOCK OVERRIDE DISABLED.** Button will change to “OVERRIDE ENABLED” and will turn green.
9.5 Press and hold the blue **RESET BUTTON** to enable the opening of the top chamber.
9.6 Open the top door to access the top chamber.
9.7 Fix a suitable substrate plate (~30 μm surface roughness) on the table after measuring the thickness of the plate.
9.8 Input the measured size in the input box in the wiper elevator control page.
9.9 Substrate thickness offset value can be entered once table height is set
9.10 Close and secure top and bottom chamber doors

9.11 Select **OVERRIDE ENABLED** on the Door control page. It will change to "DOOR INTERLOCK OVERRIDE DISABLED" and will appear grey.
9.12 To set heat settings for a build table, select **Heater** on the Menu Page Level 1. Table Heater Control Page Level 1 appears.
9.13 Select **Set Temperature, SP <9999.9>.**
9.14 Type in the temperature desired using the screen keypad (0-150°C)
9.15 Select **ON** in the Table Heater Control Page Level 1. It will turn green.

9.1.1. Machine Set Up – Conditions

9.1.1.1. Select **Wiper/Table Control** on the Menu Page
9.1.1.2. Select **STOP ALL** in the Wiper/Elevation Position page.
9.1.1.3. Select **FIND WIPER HOME**. This must be done every time on start up.
9.1.1.4. Select **Substrate Thickness.** Type in the thickness in mm.
9.1.1.5. Select **GO TO TOP POS**. Button will turn red when complete.
9.1.1.6. Select **SET DATUM.** Button will turn red when complete.
9.1.1.7. Select **GO TO FWD POSN.** Button will turn red when complete.
9.1.1.8. Select **No. of Doses.** Type in the required number of doses (1-9).
9.1.1.9. Select **DOSE.** Button will turn red when complete.
9.1.1.10. Select **WIPER AUTO.** Button will turn red when complete.

9.1.2. Machine Set Up – Automated Build Process

9.1.2.1. Select **Select Build** on the Menu Page. Build Menu page appears.
9.1.2.2. Select the required # Build Name **SELECT.**
9.1.2.3. Select **Auto** on the Menu Page. A "Safe Change Valve" prompt page appears.
9.1.2.4. Manually open valves on either side of the filter housed in the right hand side of the cabinet (if not open). Select **YES** when done. Automatic Operation Page appears.
9.1.2.5. STOP, PLAY, and PAUSE buttons are available when needed. Select **View Parameters** to view parameters if needed.
9.1.2.6. Select PLAY symbol button to start Automatic cycle.
9.1.2.7. At the end of the cycle, a "Isolate safe Change Filter" appears.
9.1.2.8. Manually shut valves either side of the filter housed in the right hand side of the cabinet. Select **CONFIRM** when completed.
9.1.2.9. When cycle is completely finished, an "Auto Cycle Complete" prompt page appears.
9.1.2.10. Select **OK.** The process is complete.

10.0 OPERATOR LEVEL 2 – Additional Features over Level 1

10.1. Pausing at Layers

10.1.1. At main menu page, select **Auto.**
10.1.2. Select **Pause at Layer** at the Auto Operation page.
10.1.3. Type in a layer number at which a desired pause is initiated
10.1.4. To stop a pause, reselect **Pause at Layer** and type in 0.

10.2.To Abort

10.2.1. Select **ABORT** on the Auto Operation page.

10.3.To Access Alarm Messages

10.3.1. At main menu page, select **Auto.**
10.3.2. Select **Alarms** on the Auto Operation page.
10.3.3. To access alarm history, select **Alarm History** on the Auto Operation page.
10.3.4. Alarms must be resolved then reset in order to machine to restart. Select **Reset** to reset.

10.4. Manual Controls

10.4.1. At main menu page, select **Manual.**
10.4.2. On the Manual Control page, select **ENABLE MANUAL** to change parameters individually.

11.0 OPERATOR LEVEL 3 – Additional Features over Level 2

11.1. Setting Zero Pressure Reading and Heater

Zero Pressure

1. Select **Open Door** on the main menu page.
2. Select **ZERO PRESSURE READING.**

Heater

1. Select **Heater** on the main menu page.
2. Change heating parameters by clicking the appropriate box.

11.2. Wiper/Elevation Position

11.2.1. Select **Wiper/Elevator Control** on the main menu page.
11.2.2. Select **HOME** on the first row (changes X-Position of wiper to 000.000).
11.2.3. Select **LOAD** on the first row (changes X-Position of wiper to -045.010 behind cassette).
11.2.4. Select **HOME** again to discharge a dose of powder in front of the wiper blade, and moves wiper to X-position of 000.000.

- Hold arrow pointing upwards to move wiper forward. Release to stop.
- Hold arrow pointing downwards to move wiper backward. Release to stop.
- Hold triangle pointing upwards to move table upward. Release to stop.
- Hold triangle pointing downwards to move table downward. Release to stop.

11.3. Service Functions

Setting Time and date
11.3.1. At main menu page, select **Service.**
11.3.2. The service menu appears, select **Set Time and Date**.

11.4. Manual Controls

11.4.1. At main menu page, select **Manual.**

8.0 REPORTING AND DOCUMENTATION:

List information required for report, method of recording, and name and numbers of form(s) to use. Information may include the results of positive and negative samples, standard preparations, calibrations, and equipment monitoring values – that is, any controls that help to ensure that the procedure was performed as specified.

9.0 REVIEWS AND REVISIONS:

This procedure shall be reviewed for compliance and effectiveness and revised as necessary (or at a specified interval).

10.0 ATTACHMENTS and REFERENCE FORMS:

List attached documents, manuals, sample forms, etc. in the following format:

ATTACHMENT A. (Name)

ATTACHMENT B (Name)