
**Nano/Micro Fabrication Facility**

# ROFIN FIBER LASER SYSTEM OPERATIONS MANUAL

| Revision | Date | Description | Curator |
|---|---|---|---|
| 0 | 7/30/2014 | New Document | Sam Brannon |
| 1 | 12/18/2014 | Updated fume extractor and code procedure | Sam Brannon |

# Contents

# 1 System Overview

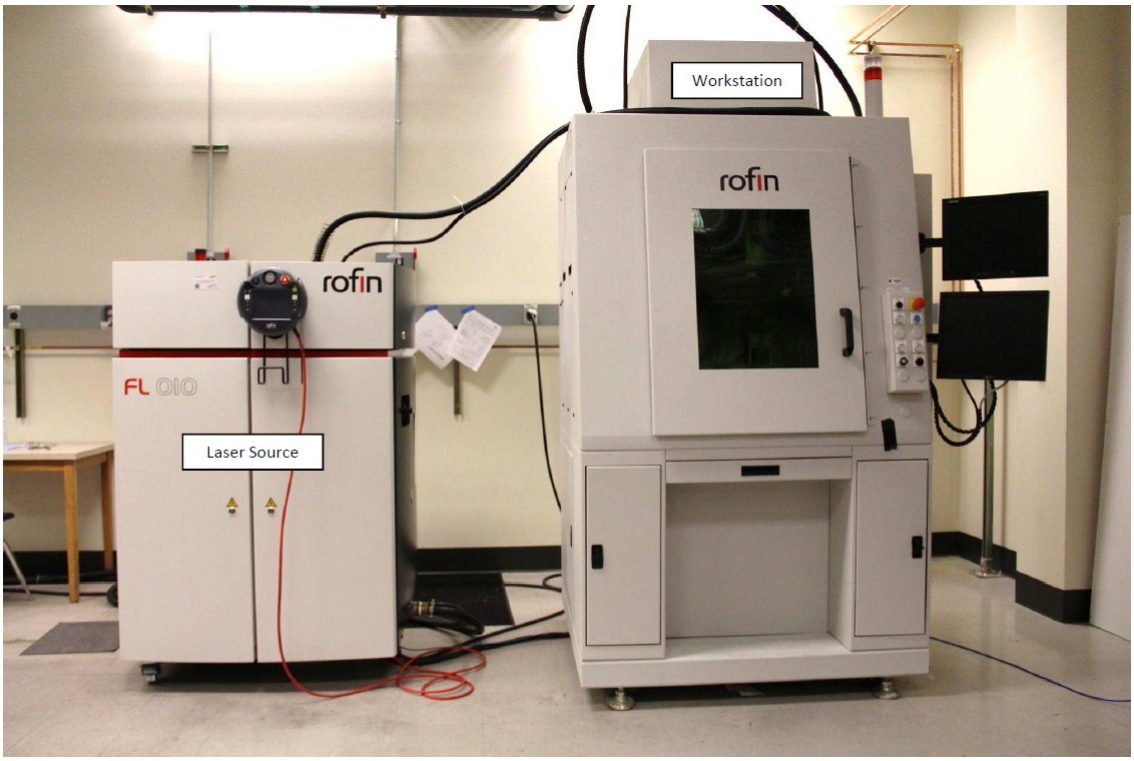



Figure 1: System Overview

The 1000 Watt Rofin laser system (class 3 laser) can operate as either a laser cutter or a laser welder/marker. When you approach the system, the operating mode can be easily identified by the lens system attached to the z-axis within the workstation compartment. Figure 2 shows the two different optical packages used on the system. ***Additional training sessions (beyond operator training) are required before a user can change the operating mode of the system.***

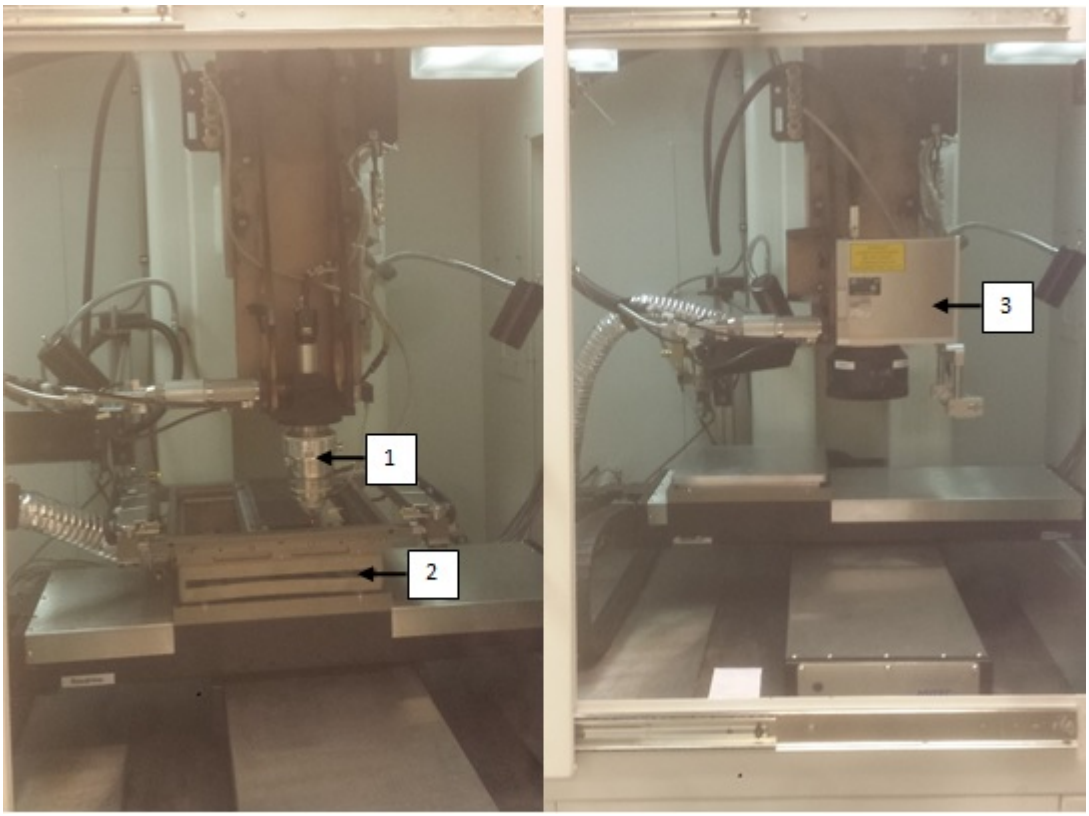



Figure 2: Cutting(Left) and Welding(Right) Optics installed on workstation z-axis. 1. Cutting optics, 2. Cutting box, 3. Welding optics.

### There are 3 main system components:

1. Workstation
2. Laser Source
3. Cooling Unit (Located inside the fab floor by the west entry)

### There are 4 pieces of support equipment connected to the workstation:

1. Fume Extractor (rear connection)
2. Process Nitrogen (rear connection)
3. Process Air (rear connection)
4. Process Assist Gas (right side connection)

# 2 Safety

- Consistent with fabrication floor policy, safety glasses MUST be warn when operating the Rofin laser system.
- The Rofin requires pressurized gas to function properly. Care must be taken when turning on and off support gasses.
- Additional training is required for assist gas use.
- The system has many safety interlocks that prevent leakage of laser radiation while the beam is on. These interlocks are present on the laser source, the workstation, and within the operating software.

**!!DO NOT DEFEAT ANY SAFETY INTERLOCKS AT ANY TIME. DOING SO CAN CAUSE BOTH PERSONAL INJURY AND SYSTEM DAMAGE!!**

# 3 System Startup Procedure

The following is the sequence required to start up the laser system, regardless of the current or desired operating mode. Mode-specific instructions follow in subsequent sections.

1. (Figure 3) Go to the chiller located on left of workstation and around corner. Switch the chiller to **local**.


Figure 3: Rofin system chiller (left) and control switch (right).

2. (Figure 4) Turn on the gas valves at the rear of the laser (Air, Nitrogen).
   (a) Air pressure regulator setting is full open. Typical reading is about 90psi.
   (b) Nitrogen pressure regulator set to 120psi.

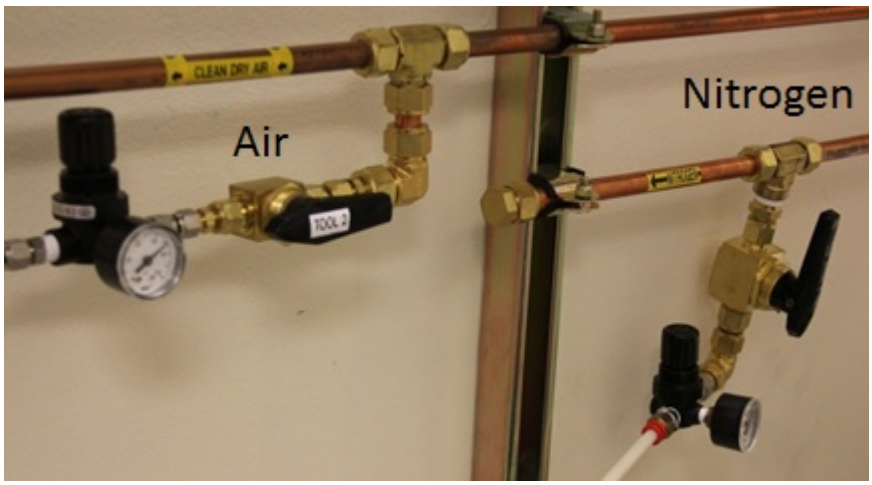



Figure 4: Rofin process Air and Nitrogen on/off valves.

3. (Figure 5) Turn on the exhaust vacuum by pressing the power button on the fume extractor. If desired, the fume extractor can remain off until prior to the start of laser processing without any error messages occuring, including performing a dry run, however attempting to run a weld program in NView without turning on the fume extractor will result in an error message.

Figure 5: Rofin system fume extractor (left) and control panel (right).

4. (Figure 6) Locate and turn on the workstation at the main power disconnect located at the rear of the workstation.

Figure 6: Workstation main power disconnect.

5. (Figure 7) Locate and turn on the laser source at the main power disconnect located on the right side of the laser source.


Figure 7: Laser source main power disconnect.

6. (Figure 8) Move to the front of the workstation and verify that the workstation and laser source **E-STOP** buttons are pulled out by turning the workstation E-STOP button **counterclockwise** and the laser source E-STOP button **clockwise**.

7. Press the blue **E-STOP** button on the control panel.

8. (Figure 8) Press the white **POWER ON** button.

   (a) The button will light up and the white status light on the top of the workstation will turn on.


Figure 8: Workstation front control panel.

9. (Figure 9) Log into the **Laser Source Pendent** control software. This is done by using the stylus to enter the user name **operator** and password **operator**. The software will load and the laser source home screen will be shown.

10. Verify or change the **Program Mode** of the laser source to the appropriate mode for your process. There are three modes, but only two that are used at the MBI. These are:

    (a) VLM **(used for galvo welding, marking, and metal ablation**)

    (b) PRC server (**not used**)

    (c) internal programs (**used for cutting and fixed welding**)

    The program mode can be seen by either opening the **Program** page and seeing which option has been selected in the top left corner under **Operation mode** or by observing the color of the box next to the **Program Mode** line and the color of the box on the lower left side on the **Menu** page. These will be **green** if the program mode is set to **VLM Mode**, and yellow if it is set to **Internal Programs**. Figure 10 shows the difference in Menu screen appearance. Refer to Section 7 for details on how to navigate and modify settings/programs on the laser source.


Figure 9: Laser source pendent log in screen. 1. Laser source control key, 2. Laser source E-Stop button.

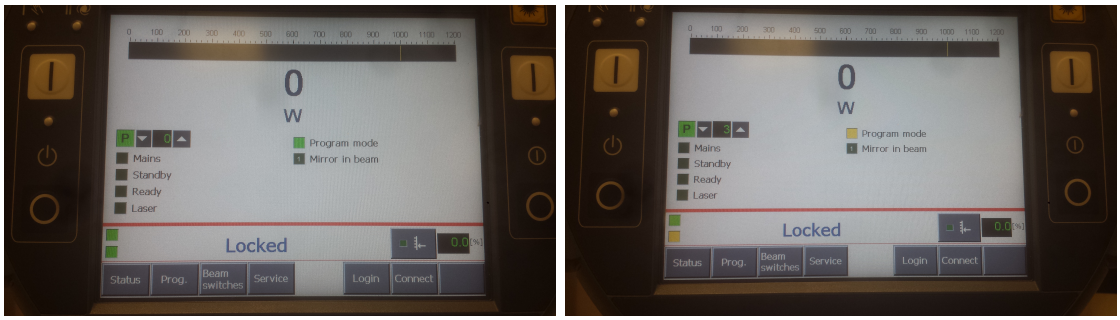



Figure 10: Menu screen for VLM (left) and Internal Programs (right) operating modes.

11. Upon workstation computer start-up, type in the user **administrator** with password **admin** for the windows log in.

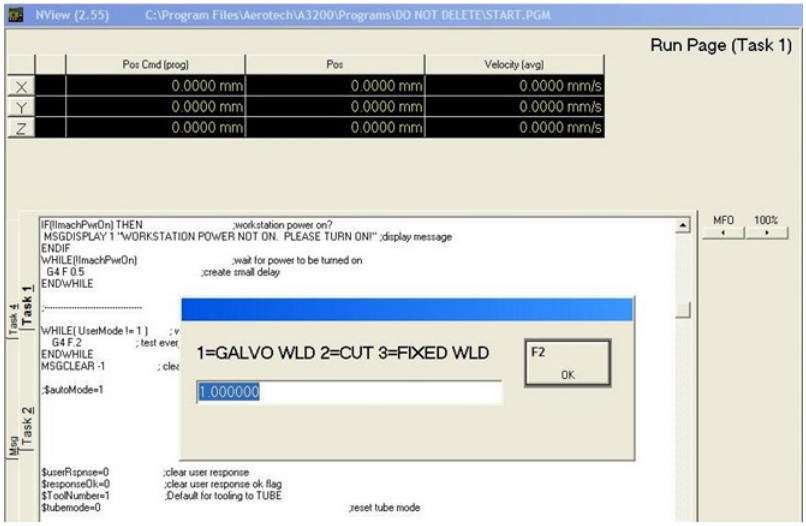



Figure 11: NView startup page and first prompt.

12. (Figure 11) The NView software will automatically open to the **RUN** page and prompts will be displayed asking for user input. Follow the prompts to initialize the workstation:

    The first prompt selects the operating mode from three choices:

    (a) Galvo Welding (For this process Continue on to step 13.)

    (b) Cutting (For this process skip to step 14.)

    (c) Fixed Welding (For this process skip to step 15.)

13. For **Galvo Welding Mode** initialization, do the following:


In the first prompt type **1** and press **OK (F2)**.


Check to ensure the galvo head is properly installed by checking for the presence of a data cable attached to the top of the galvo head. If it is installed click **YES**, otherwise shut down the system, install the galvo head data cable, and then select **YES**.

.


The third prompt will request to initialize and home the three axes. ***Open the workstation door and inspect for/remove any obstructions that will impede axes motion. The x-y axes home in the far left corner of the work area.*** If no obstructions present, close the door and select **YES** to home the axes. The Z-axis will home first, followed by the Y-axis and finally the X-axis.

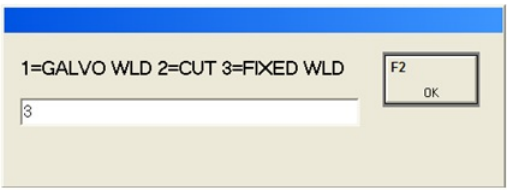
14. For **Cutting Mode** initialization, do the following:


In the first prompt type **2** and press **OK (F2)**.


Check to ensure the cutting box is installed. If it is installed click **YES**, otherwise install the cutting box and then select **YES**.


The third prompt will request to initialize and home the three axes. ***Open the workstation door and inspect for/remove any obstructions that will impede axes motion. The x-y axes home in the far left corner of the work area.*** If no obstructions present, close the door and select **YES** to home the axes. The Z-axis will home first, followed by the Y-axis and finally the X-axis.

15. For **Fixed Welding Mode** initialization, do the following:




In the first prompt type **3** and press **OK (F2)**.


The third prompt will request to initialize and home the three axes. ***Open the workstation door and inspect for/remove any obstructions that will impede axes motion. The x-y axes home in the far left corner of the work area.*** If no obstructions present, close the door and select **YES** to home the axes. The Z-axis will home first, followed by the Y-axis and finally the X-axis.

Once the axes are homed, the message display in NView will read **Please select a part program on Task 1**. This indicates proper system initialization. To prepare the laser for operation, steps 16 through 20 are used to **enable** the fiber laser. This means that the laser will fire when a program requests it.

16. (Figure 9) Turn the control key on the **laser source pendent COUNTER-CLOCKWISE** to put the source in **automatic mode**. The lower message display on the pendent screen will read **Mains Enabled**.

17. (Figure 20) Turn the **LASER MAIN ON** switch located on the workstation front control panel **CLOCKWISE**. The lower message display on the laser source pendent screen will change to read **Cooling Start**. This message will remain for 30 seconds.

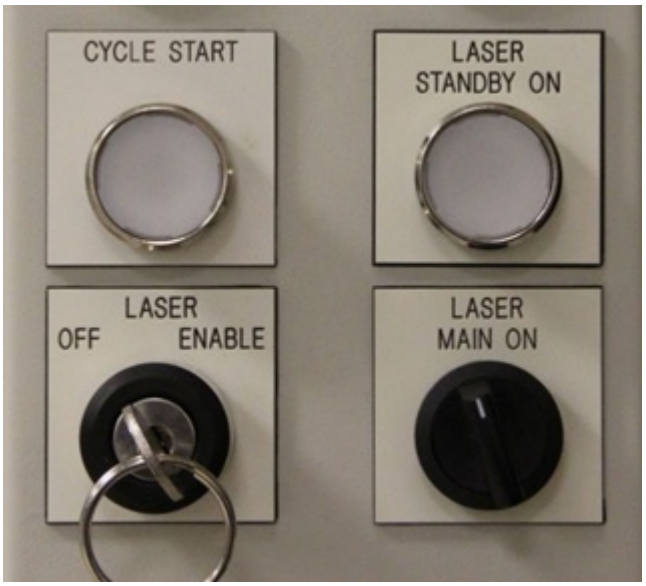



Figure 20: Lower portion of the workstation front control panel. These buttons/switches control the laser status.

18. (Figure 20) After 30 seconds the lower message display will read **Standby Enabled**. When this is displayed, press the **LASER STANDBY ON** button on the workstation front control panel. If everything has been done properly up to this point, an audible **CLICK** will be heard coming from the laser source and the red status light on both the laser source and the workstation will turn on and stay on. If no click is heard and the lights do not stay on, consult a lab tech to troubleshoot.

19. (Figure 21) While the NView software is still on the **RUN** page, navigate to the second options menu on the **F7 options panel** and select the **F10 System OK** button. The button will turn green.

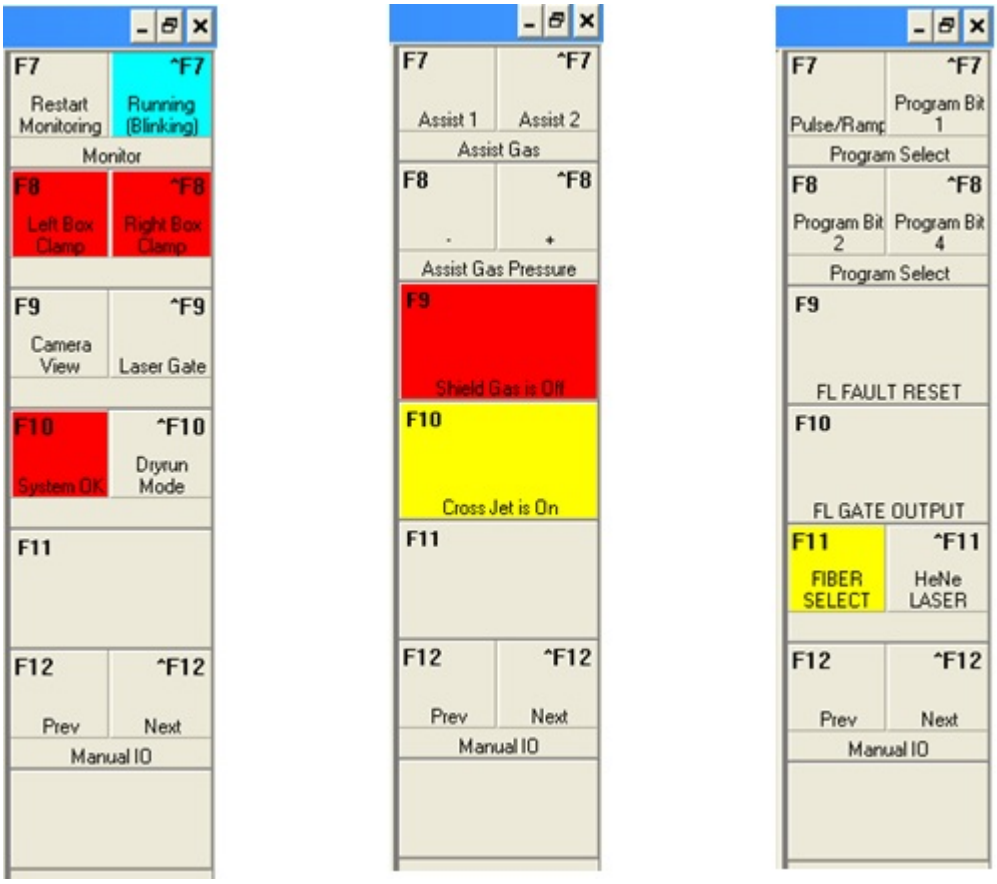



Figure 21: Additional options menus on the **F7 options menu**.

20. (Figure 20) The last physical step to enabling the laser is to turn the **LASER** key on the front control panel to **ENABLE**. The lower message display on the laser source pendent will now read **Laser Enabled** and the laser can now be fired.

    **NOTE**: It is typical to leave this key unturned until before the final cut/weld program is ran to prevent any accidental laser firing during attempts at dry runs in all three operating modes. This key has no software error associated with it being in the **OFF** position, so it will not cause issues with program execution. Doing this prevents accidental scrapping of raw material and parts.

21. continue to Sections 5 and 6 to find additional instructions for each specific operating mode. Section 4 provides the procedure to shut down the Rofin system.

# 4 System Shut Down Procedure

The Rofin system is shut down in the reverse order that it is started up. Follow these simple steps to turn off the Rofin system

1. Remove all parts, trash, excess material, tools, etc. from the workstation.
2. If you were welding, remove any workholding from the x-axis stage.
3. If used, turn off and remove any assist gas or process gas setups.
4. Home the axes (Home button on the **manual motion** page in NView.)
5. (Figure 8) Turn the **LASER** key switch counterclockwise from **ENABLE** to **OFF**.
6. (Figure 8) Turn off the **LASER MAIN ON** switch counterclockwise. An audible 'click' will be heard and the red status light will turn off.
7. (Figure 9) Lock the laser source by turning the **laser source control key** ONE click clockwise, leaving the key oriented vertically.
8. Shut down Nview and all remaining open software.
9. (Figure 8) Press the **POWER OFF** button on the workstation main control panel.
10. Shut down the computer.
11. (Figure 7) If 30 seconds has passed since the **laser source control key** was switched to **locked**, then turn the laser source off at the main power disconnect. If 30 seconds has not passed, wait it out.
12. (Figure 6) After the computer has shut down, turn off the workstation at the main power disconnect.
13. (Figure 5) Turn off the fume extractor.
14. (Figure 4) Turn off the process gasses Air and Nitrogen.
15. (Figure 3) Turn the system chiller to **STAND-BY**.

The system is now shutdown and ready for the next user.

**Please be sure to clean up the work table and area around the Rofin before leaving the area.**

# 5 Laser Cutting Procedure

This section outlines the basic procedure the Rofin laser, work pieces, and code for metal cutting. This procedure assumes that the cutting optics and cutting box are installed within the workstation and the workstation is classified as "IN CUTTING MODE." The motion of the laser is controlled by the motion table through G-code. G-code can be generated in SmartCAM with the Rofin specific post processor. This procedure assumes a basic proficiency with the NWview motion control software. This procedure references the following manual sections and external documents:

- System Startup Procedure (Section 3)
- NView Basics (Section 8)
- Generating G-Code (Section 10)
- Laser Source Pendent Operation (Section 7)
- System Shutdown Procedure (Section 4)
- Laser_Program_Tracker (External Excel file)

Figure 22 explains the important features of the cutting box to note.

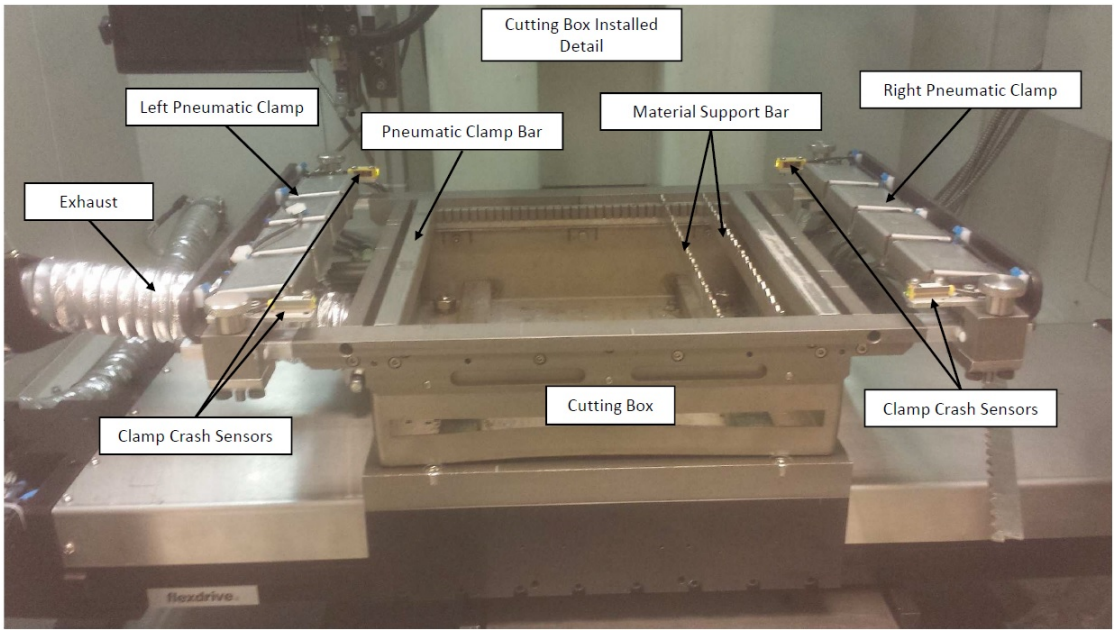



Figure 22: Cutting Box Parts.

1. Turn on the Rofin Fiber Laser system as per the startup procedure outlined in Section 3.
2. Produce G-code and transfer it to the workstation.
    - SmartCAM instructions for converting a .dxf file from Solidworks to g-code can be found in Section 10.

- The code generated in SmartCAM is assumed the system is in **incrimental mode** and does not commence machining from a set origin. This means that the first command in the g-code generated in SmartCAM is a laser on command. Unless the g-code is modified, the alignment location (position of laser when the program is started) is where the first cut called for in the code is started. **Be aware of this and designate a cutting program origin accordingly. Typically a G00 move from an origin placed at the corner of the drawing is added to the start of the program to make things easier.**

3. Figures 23, 24) Using the **Manual Motion Page** in Nview, move the **cutting box** up front by the workstation door and load the raw material onto the cutting box using either magnetic or pneumatic workholding:

- **Pneumatic Workholding**

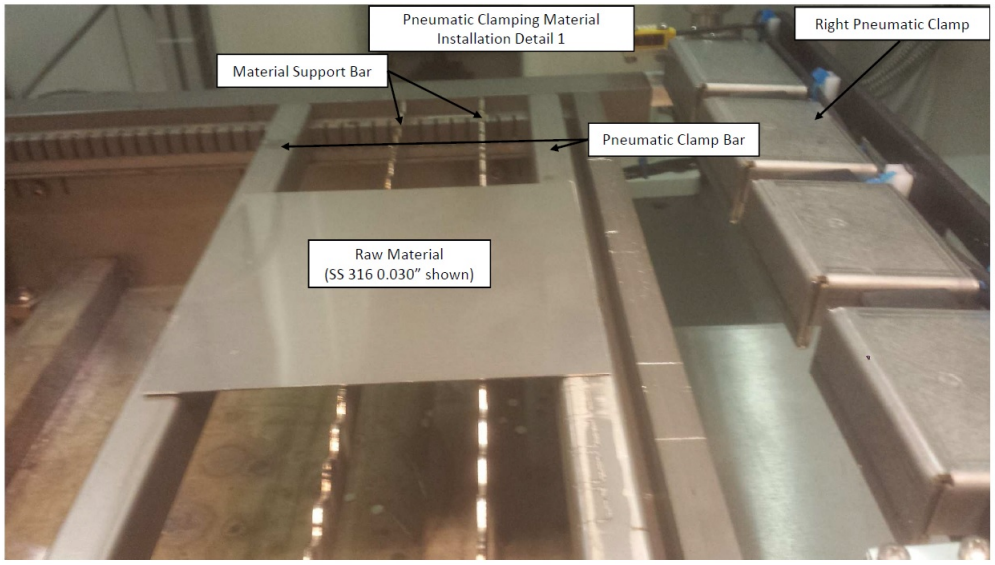



Figure 23: For **pneumatic workholding**, move the **pneumatic clamp bars** to fit the raw material size, ensuring there is sufficient overlap for the clamps to grip the material. add **material support bars** in the middle of the material to prevent excessive deflection from the assist gas pressure. Use as few as possible to prevent excessive wear on these consumable parts.

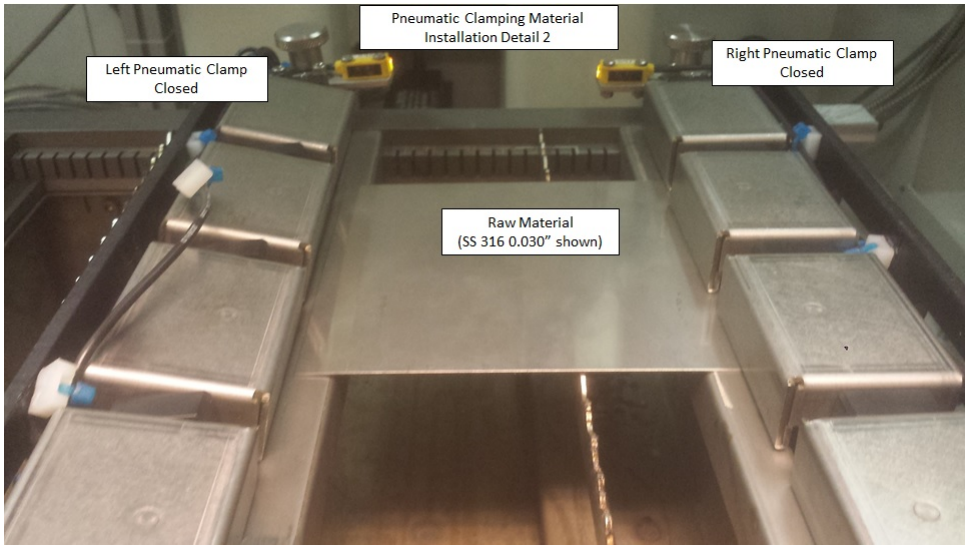



Figure 24: Next move the **pneumatic clamps** and secure them over the ends of the material by tightening the screw knobs located at either end of each clamp, ensuring they make contact with the **pneumatic clamp bars**. In NView, navigate to the second options menu on the **F7 options panel** and select the **Left Box Clamp and Right Box Clamp** buttons. The button will turn green and the pneumatic clamps will close, securing the material. Give the material a few taps to be sure it is secured with minimal deflection.

- **Magnetic Workholding**

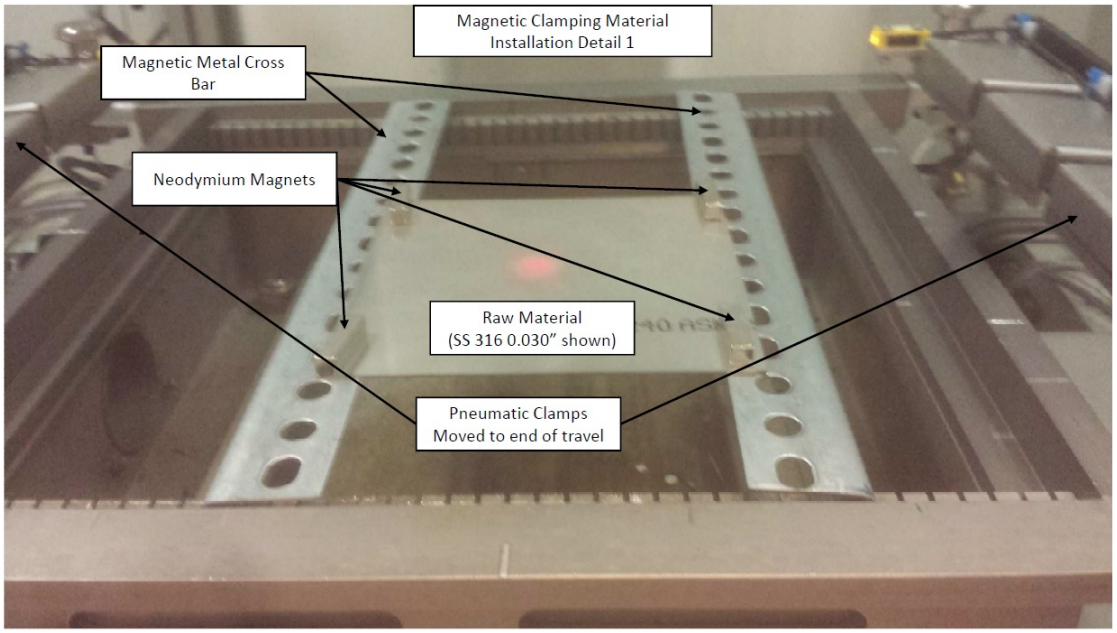



Figure 25: Move the pneumatic clamps to the end of their travel and secure them. Install the **magnetic metal cross bars** in the cutting box so that the raw material ends rest upon them. Using the Neodymium magnets located on the cabinet adjacent to the workstation on the right, secure the raw material edges. Add **material support bars** as needed to provide support interior to the material edges.

**Once the material is installed, resume the cutting procedure as follows:**

4. Mark an origin on the raw material with a marker. This location should correspond to the starting location of the cutting program. If using an edge of the material for alignment, skip this step as this process is described in step 6 below.

5. (Figures 26, 27) Lower the cutting head (Z-axis) so that the height sensing tip is between **0.3 and 0.45[mm]** above the material surface.

   (a) select the **Z-axis jog type** on the **Manual Motion Page** to **free run** and move the head down within **1[cm]** of the material surface.

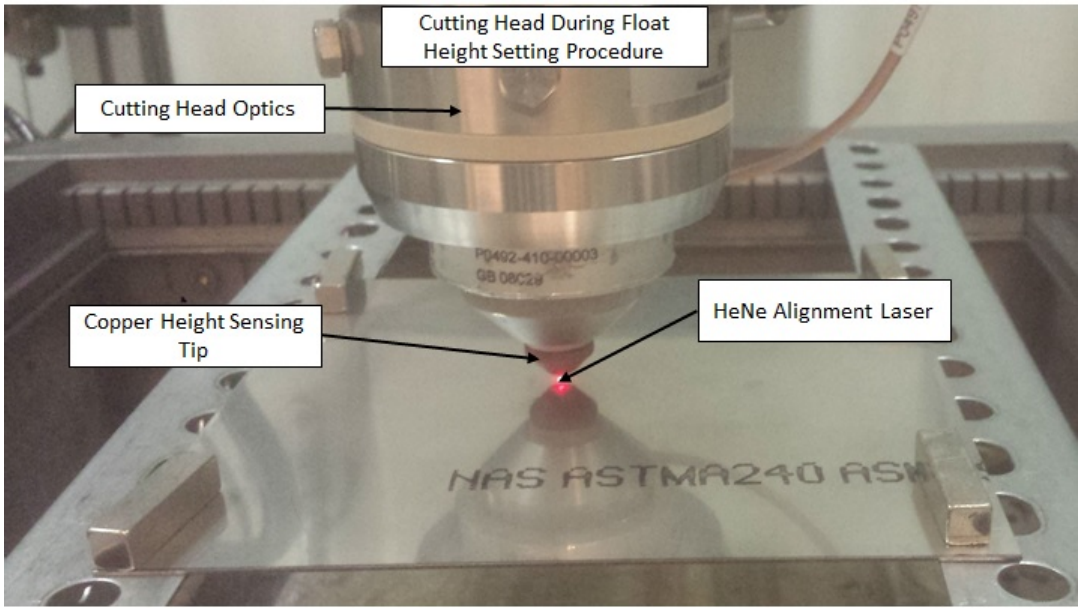



Figure 26: Initial step of cutting head height setting process.

   (b) Change the jog type to **distance** and use decreasing distance increments from 1[mm] to 0.1[mm] to lower the cutting head until the **Precitec height Sensor control Box** display reads a value between 0.30[mm] and 0.45[mm].

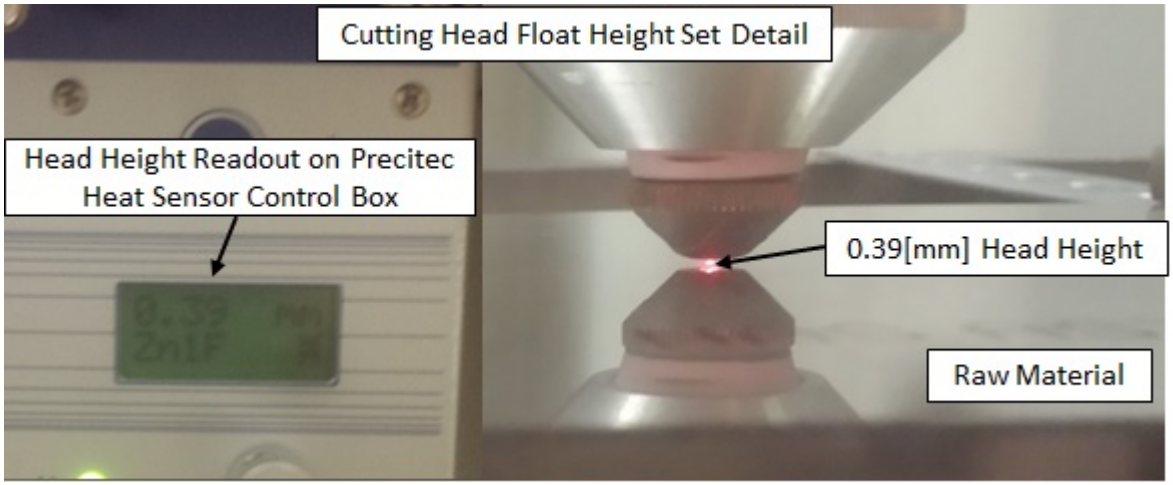



Figure 27: Cutting height properly set showing Precitec readout(left) and optics(right).

6. (Figure 28) Using either the HeNe alignment beam or the camera feature and a slow table motion speed, align the cutting head to the selected origin. The camera is best used to find material edges. To find an edge move the head in small increments near the edge until it can be seen in the camera viewer.

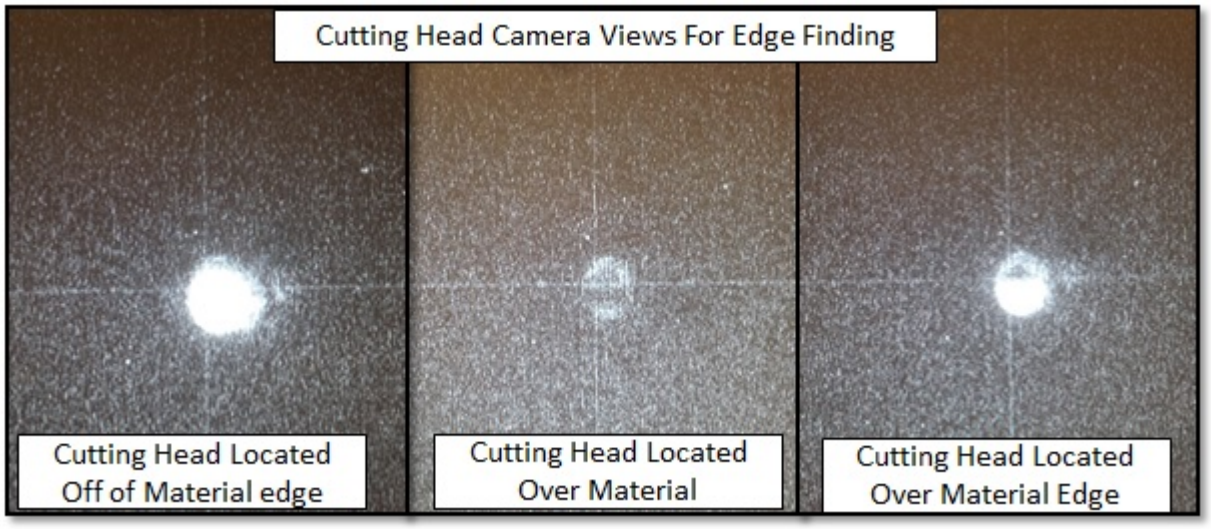



Figure 28: Cutting height properly set showing Precitec readout(left) and optics(right).

7. If it is desired to have a consistant starting location for this program (i.e. multiple setups), record the X, Y, and Z positions to add them to the cutting program preamble. Otherwise, using the default position commands in the template will start the program from the current X-Y position.

8. Load the **blank cutting program template** into NView. Refer to Section 11.1 to learn about the different program section requirements and to view a program example.

9. Save the program under a new name within your user folder within the **Current Users** folder on the computer desktop.
   **!!DO NOT SAVE OVER THE TEMPLATE DOCUMENT!!!**

   **NOTE:** All program names are automatically converted to ALL CAPS.

10. (Figure 29) Modify the program preamble variable values:

```
;---------------------------------------VARIABLE PREAMBLE-----------------------------------
DVAR $size                                              ;Example of a new variable def
$size = 20                                              ;Example of assigning a value
laserPower = 150                                        ;Set laser power here (50-1000
$zFocusPos=-281.45                                      ;Z Focus position for referenc
ThresholdSoftCW.Z=-289.0                                ;Z soft limit
$initXpos= $STATUS[_PositionUnits].X                    ;Initial X position for progra
$initYpos= $STATUS[_PositionUnits].Y                    ;Initial Y position for progra
$positionSpd=30                                         ;positioning speed (mm/s)   ( 0
Spd=100                                                 ;Processing Speed (mm/s)    ( 0
$pierceDelay=0                                          ;pierce delay (seconds) typica
$assistGas=ASSIST1                                      ;assist gas (ASSIST1 OR ASSIST
$cutPres=100                                            ;assist gas cutting pressure (
$partsToCut=1                                           ;how many times to repeat
$piercePrgmNum=5                                        ;program selection for piercin
PrgmNum=4                                               ;laser program selection for c
```

Figure 29: Variable Preamble section of a cutting program.

(a) Modify the value of **laserpower** to correspond to a desired laser power for your cutting program. This line is only used if the laser program on the laser source has the **Pulse scaling** set to A1, otherwise laser power is set within the laser source program and should be modified there. See Section 7 for details on this procedure.

(b) Modify the value of **$zFocusPos** to correspond to the recorded Z-position from step 7.

(c) If desired, modify the value of **$initXpos** to correspond to the recorded X-position from step 7. Otherwise the default value ($STATUS[_PositionUnits].X) will start the program from the current location.

(d) If desired, modify the value of **$initYpos** to correspond to the recorded Y-position from step 7. Otherwise the default value ($STATUS[_PositionUnits].Y) will start the program from the current location.

(e) Modify the value of **Spd** to correspond to the required cutting speed given by your cutting recipe (Reference the excel spreadsheet **laser_ program_tracker** for validated recipe options).

(f) Modify the value of **$cutPres** to correspond to the required pressure given by the cutting recipe. **NOTE:** A fault will occur if the pressure specified is higher than what the house air can provide. Typical cut pressure is around 100[psi].

(g) Modify the value of **$piercePrgmNum** to correspond to the required pierce program given by your cutting recipe.

(h) Modify the value of **PrgmNum** to correspond to the required cutting program given by your cutting recipe.

11. Open the G-code generated for the part in Notepad and copy the code into the program in NView within the **MOTION CONTROL** program section. **NOTE:** The template includes repeat loops and sub-routine callouts to use if needed. SmartCAM does not use these, so if desired you must incorporate them into your code now.

12. Load the program into **TASK 1** by doing the following:

    (a) Select **SAVE**.

    (b) Select **Error Check**. This will compile your program and display any errors or warnings encountered in the **messages** window above the **F2 option bar**. Fix any errors if present. Some warnings can be ignored.

    (c) Select **RUN**. This will load your program under **TASK 1** and automatically navigate you to the **RUN** page in NView.

13. Modify the laser source internal programs according to your cutting recipe.

14. Validate program motion through a **DRY-RUN** by doing the following:

    (a) Move the cutting head (Z-axis) away from the cutting material by at least **50[mm]**. This will prevent any crashes of the head into the pneumatic clamps.

(b) Navigate to the second options menu on the **F7 options panel** and select **F̂10 Dryrun Mode**, which will turn yellow after selection.

(c) Select **TASK 1** from the tabs on the left side of the run screen. verify that the appropriate program has been loaded and verify the starting position in the code preamble matches the current position readout on the top of the screen. If they mismatch, the machine will automatically move to the specified coordinates in the program when the program is started.

(d) Check for any obstructions within the workstation that could hinder correct table motion or that could crash into the cutting head. Fix any suspected issues.

(e) Select **F2 Cycle Start** from the **F2 Options Panel**. The table position will now adjust to match the starting position called out in the program.

(f) The code line **M0 ;Wait for cycle start button** will be highlighted and acts as a prompt to select **F2 Cycle Start** to start the cutting program. **At this point it is important to pay full attention to the workstation and be ready to stop the program if issues arise**.

(g) The program will now execute. Monitor table motion and ensure proper code execution. If unexpected table motion occurs select the **F4 ABORT** button. The **F4** button will change to be a **Reset** button. Press this to reset the program. After an abort, all gasses and clamps remain activated and must be turned off manually or by restarting the program. **IF ANY ISSUES OTHER THAN TABLE MOTION OCCUR PRESS THE E-STOP BUTTON IMMEDIATELY AND CONTACT MBI STAFF TO RESET THE SYSTEM.**

15. Based on the results of the dry run, make modifications to the program code and perform a second dry run if needed. If table motion was good, proceed to the next step. **NOTE:** After any program is fully executed, the three axes will need to be initialized if any manual table motion is performed by clicking the axes label next to the position read out on the top of the screen. See Section 8.3 for further details. There is no need to re-initialize if the program will just be re-ran without any manual motion performed.

16. Turn on the fume extractor (Section 3 Item 3) if it is not currently running. An error will occur if the extractor is not turned on during final laser firing.

17. Run the validated program by following the following steps:

(a) reinitialize the Z-axis and lower the head back to the material surface following the process laid out in step 5 above. See Section 8.3 for instructions on axis initialization.

(b) Deselect the **Dryrun Mode** button. The button color should return to grey.

(c) turn the **LASER** key on the workstation front control panel to the **ENABLE** position if it has not already been done.
**!!THE LASER IS NOW ENABLED AND WILL FIRE DURING THE NEXT PROGRAM RUN!!**

(d) Select **F2 Cycle Start** from the **F2 Options Panel**. The table position will now adjust to match the starting position called out in the program.

(e) The code line **M0 ;Wait for cycle start button** will be highlighted and acts as a prompt to select **F2 Cycle Start** to start the cutting program. **At this point it is important to pay full attention to the workstation and be ready to stop the program if issues arise**. **NOTE:** After the program starts, the **messages** screen will be displayed ad will provide any warnings or fault messages during execution. Typically the only messages displayed during proper program execution are **Laser Ready** and **Laser On**. If any minor faults occur, typically the laser will not fire and the table motion will pause. If this happens, it is often possible to resolve the issue and clear the fault without restarting the program, at which point the program execution will resume.

18. After program completion, move the cutting head (Z-axis) up from the material surface and remove the cut part from the box. Repeat the alignment and execution steps as needed for additional runs/parts.

    **After all cutting is completed:**

19. Remove any spare raw material from the cutting box, including any large debris that was left in the bottom of the cutting box. Small debris/particulate/slag is fine and will be cleaned routinely by a lab technician. Scrap metal can be placed in the scrap box under the table across from the workstation.

20. Home all axes.

21. Return the pulse and cutting programs back to their standard values on the laser source pendent. These values are listed in the Excel spreadsheet titled **Laser_Program_Tracker**.

22. If no user is waiting to use the tool, shut down the system following the shutdown procedure found in Section 4. If a user is waiting to use the tool, reset the system in NView.

# 6 Welding Process Procedures

There are two welding operating modes on the Rofin laser system. These are:

- **Galvo Welding Mode:** In this mode, x-y motion stage is stationary and the laser beam motion is controlled by two servo-driven mirrors within the galvo optics housing. This mode can operate at much higher beam travel speeds (in excess of 1[m/s]) but is restricted to a small working window of 120x120[mm]. Galvo welding is controlled by separate software than NView, called **Visual Laser Marker** which is a CAD-like software package. Information on the basic use of this software can be found below in Subsection 6.2.
- **Fixed Welding:** In this mode, the servo mirrors inside the galvo optics housing are stationary and motion is delivered by the x-y stage. This mode has a much larger operating window ≈450x450[mm] but is restricted to travel speeds of less than 150[mm/s]. Like laser cutting, all fixed mode welding is controlled by **G-code** and programs made and executed in NView. Unlike laser cutting, there are a few differences in how the machine controls motion which will be discussed in Subsection 6.3.

As the majority of the tool setup for both welding modes is the same, the next two subsections are dedicated to these similarities. The first describes how to set the **focal distance** and the second covers how to setup any required shielding gas. Subsequent subsections cover process specifics. The galvo-welding process described in Subsection 6.2 also applies to laser marking and metal ablation, although these processes are not discussed in detail in this manual.

## 6.1 Welding Setup Procedure

Workstation and laser source setup for welding includes ensuring proper **operating mode** of the **laser source** and setting the proper focal distance for the **galvo optics**. As discussed in the start-up procedure, the proper operating modes for the two welding modes are:

- **VLM** for galvo welding, marking, and ablating
- **Internal Programs** for fixed welding

Regardless of mode, the welding optics have a focal distance from the **reference surface** to the **beam focal plane** of 304.5[mm]. Most welding requires the beam to be focused on the top surface of the top layer to be welded, however the optics on the Rofin at the MBI have a working distance of ±0.60[mm]. To set the focal distance for the galvo head, do the following:

1. Install all process-specific workholding onto the x-y stage and locate the stage below the galvo head.
2. (Figure 30) Locate the height setting standard, a square aluminum bar cut down to 304.5[mm]. Install on your datum surface in a location that is aligned with the reference surface.

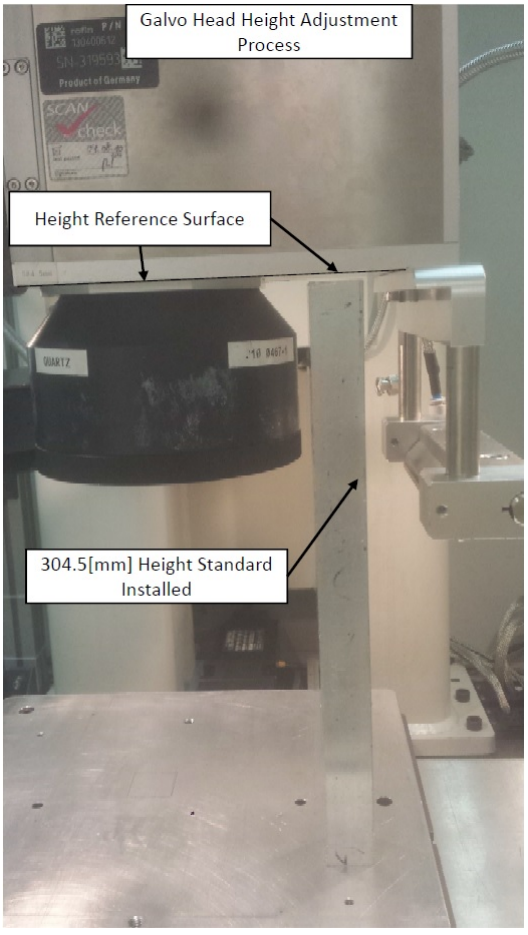



Figure 30: Focal distance setting procedure.

3. Using **Free Run**, manually lower the **galvo head** to within a centimeter of the height standard, and stop.

4. Switch to **Distance Hold** and use increments of **0.5[mm]** until the **galvo head** is within 1[mm] of the height standard.

5. (Figure 31) switch the distance to **0.050[mm]** and lower the galvo head onto the height standard until a **light contact** occurs. The height standard should be in contact with the reference surface, but not rigidly in place and should wiggle.

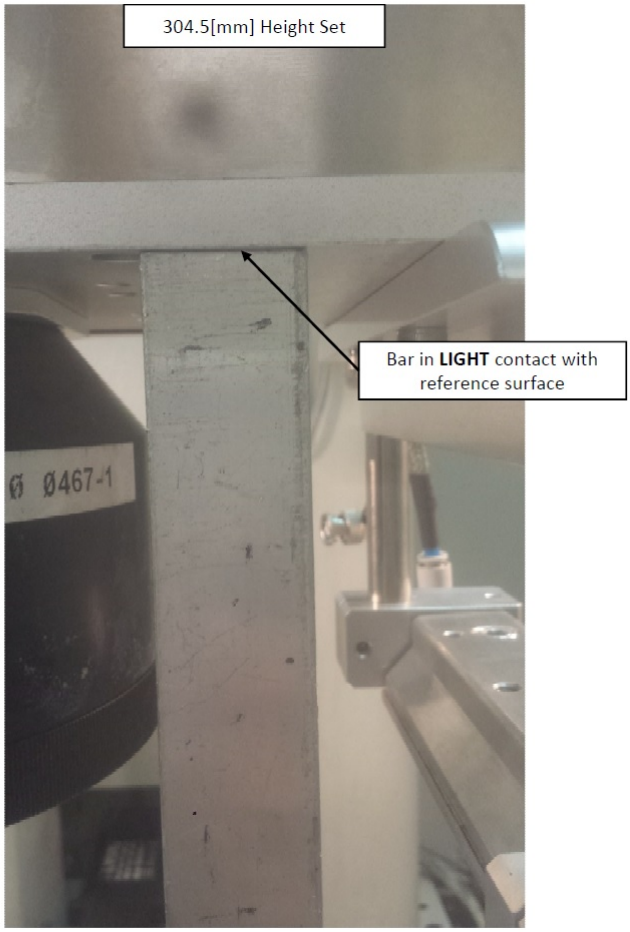



Figure 31: Focal distance setting procedure showing a loose fit between the height standard and the reference surface.

6. Increase the distance increment to **10[mm]** and change the motion control to **distance** and raise the **galvo head**.

7. Remove the **height standard** and lower the head again 10[mm].

**The proper focal distance is now set to your datum surface. Adjust the height of the galvo head accordingly to match your process setup.**

## 6.2 Galvo Welding Procedure

Once the **focal distance** for the **galvo head** is properly set and applicable shielding gas is setup, the following steps will finalize the workstation setup for galvo welding. Once these steps are completed, Section 9 will cover how to setup and execute welds/marks within the VLM software. **!!BEFORE FIRING THE LASER ENSURE THAT THE FUME EXTRACTOR IS TURNED ON! NO ERROR WILL OCCUR IF IT IS NOT ON DURING GALVO WELDING!!**

1. (Figure 21) On the **F7 options menu** enable the following options from the various menus:

   (a) **System OK**

   (b) **Cross Jet (when enabled, button text will change to Cross Jet is On and button will turn yellow)**

   (c) **FIBER SELECT**

   (d) **HeNe LASER**

   The laser source pendent should now read **laser enabled**.

2. Move your workholding into position by aligning the **HeNe alignment laser** with the center of your marking area. In the VLM software, the HeNe laser corresponds to the center of the 120x120[mm] marking area.

   **NOTE:** If the laser mains have not been enabled, the mirrors in the galvo head are in a relaxed position and the HeNe does not accurately relate to functional space.

3. (Figure 32) Open the Visual Laser Marker software and initialize the hardware by pressing the **Enable Hardware** button on the top toolbar.

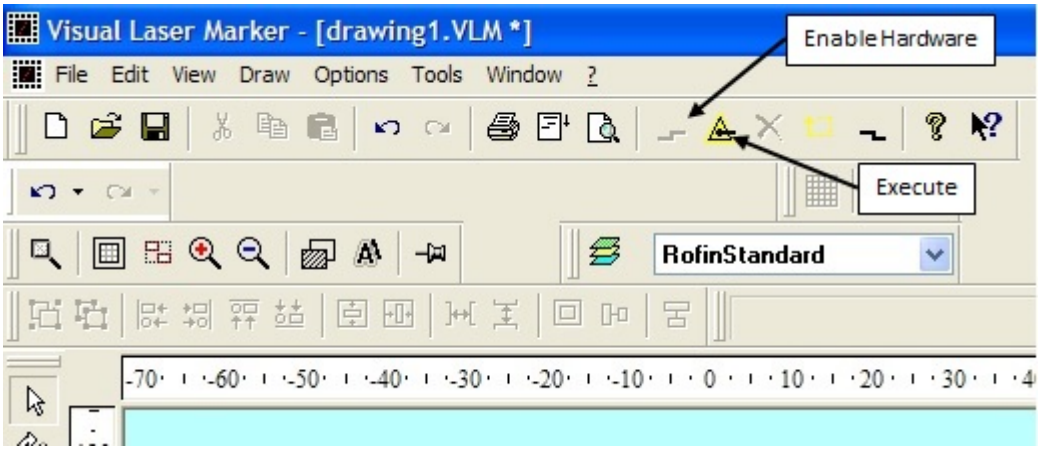



Figure 32: Top toolbar of the VLM software showing the **Enable Hardware** and **Execute** buttons.

4. (Figure 32) Using Section 9, Load/draw your tool path and prepare your laser parameters. Execute the program by pressing the **execute** button located on the top toolbar.

## 6.3 Fixed Welding Procedure

**Fixed welding mode** on the Rofin laser is similar process to cutting with regards to setup and execution of a program. There are differences in programing and program execution by the software, which are discussed below. Key setup differences include no use of the cutting box and there is only one internal program reserved for fixed mode welding. This is **program 7 (Fixed Welding)**. Because there is table motion during the welding program execution, workholding must be ridged and not allow for material movement. Figure 33 shows an example of initial workholding for a large part welded in fixed mode.

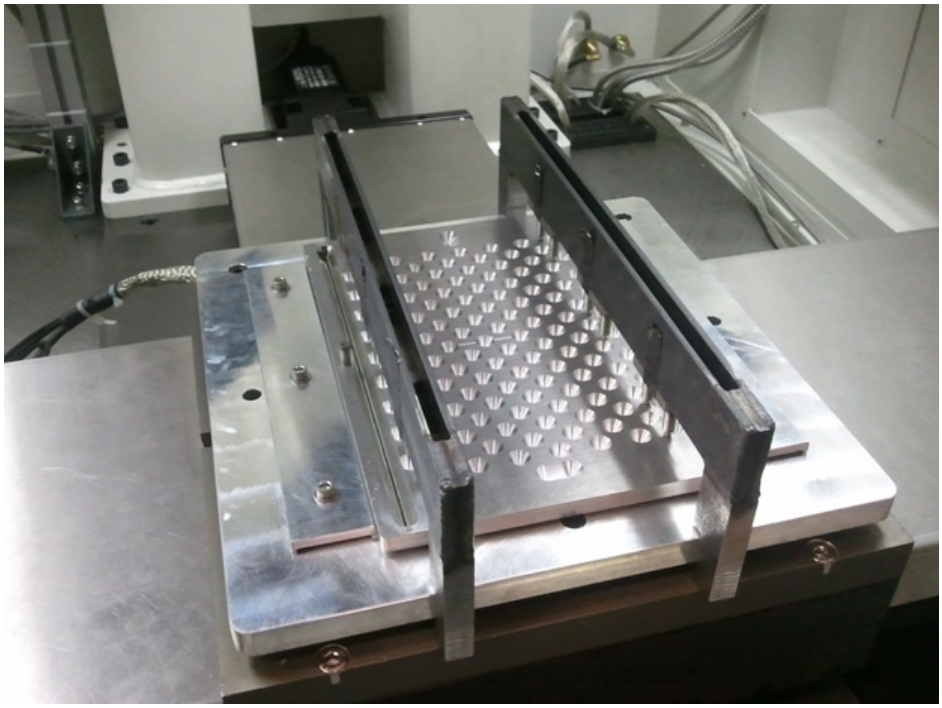


Figure 33: An example of fixed mode workholding for a large, 9x7[in] multilayered device. This setup includes a base plate datum, welding clamps, welding plate, and bar clamps to provide pressure.

This section will cover some important process development notes, accurate as of the current revision of this document and will be followed by the setup and execution instructions for a typical fixed mode welding program.

### 6.3.1 Process Development Notes

Due to current software limits, current fixed mode welding designs incorporate the following notes to help improve weld quality:

- **Narrow (1-2[mm] max) grooves are machinated into a weld plate where welds are to occur on the work piece. These grooves should taper from wide to narrow, how much so will depend on weld plate thickness. Weld plates should also be a material with a higher thermal conductivity than the material to be welded.**

Uniform clamping pressure close to the welding on both sides prevents gaps from forming during welding, and maintains good inter-layer contact. Narrow grooves provide this support best. Workholding close to the weld line also acts as a heat sync and helps to remove heat from the material during welding, which reduces potential defects caused by temperature. The grooves should be tapered in order to allow for the conical shape of the laser beam close to the focal plane. Deep, narrow grooves can interfere with the laser beam and reduce the power density at the focal plane. Any tall clamping mechanisms also need to be installed a short distance from the grove to prevent the same issue. A plate with a higher thermal conductivity will reduce the likelihood of welding the plate to your parts. An example would be an Aluminum weld plate for welding stainless steel.

- **Weld lines are typically straight and performed one at a time, overlapping to produce hermetic corners.**

  Currently fixed welding allows for splines and corners by utilizing a power ramp function that controls the laser power as a function of table speed. The two parameters that control the power ramp are the variables specified in the preamble: **laserPower** and **minPowerRampPerc**. Laser power controls the welding laser power at full (specified) speed, and minPowerRampPerc controls the minimum allowable percentage of laser power that the machine will output. The power ramp is a linear function. As this is new programing function as of October 2014, there has not yet been a thurough study of a proper minimum percentage, nor has there been any exploration of using a non-linear power ramp function to improve weld quality.

- **Oversized weld plates to allow laser on and laser off to occur outside the designed weld line and onto of the weld plate.**

  This finding may be obsolete as of October 2014 with the addition of the power ramp function discussed in the item above, however until this process is proven effective to avoid end effects, starting and stoping the weld outside the workpiece may still be benificial to hermiticity. NView and the motion control driver allows for the laser power and table speed to be coupled, i.e. the laser power is reduced when table speed slows. As there is a minimum power specified for this ramp, there may still be end effects (blow-out, holes, porosity, large heat effected zone) near the ends of weldlines. Moreover, having control of weld depth is key for hermiticity, and the ability to predict weld depth during acceleration and deceleration of the beam can be difficult. For this reason, the weld depth during the acceleration and deceleration of the work piece is much deeper than the steady speed depth, which is what the weldment is typically designed for. Turning the laser on/off some distance from the actual start/end of the weld allows the table to be at a constant speed for the actual weld area. If the weld plate is oversized, than firing the laser onto the work piece can be avoided by firing the beam on the weld plate and then moving the work piece into the laser beam. **Typically 1-2[cm] is added to the weld lengths on either side to achieve this.**

- **Table speed is limited to a maximum of 150[mm/s] so welding powers**

**compared to galvo are much lower.**

The table motion has a maximum useful speed of 150[mm/s] so if any galvo welding is done to do quick weldment process development on small scale parts the speed should be kept at or below 150[mm/s] and powers should be selected accordingly. In fixed welding it is typical to keep the speed at maximum and adjust power in order to shorten processing time, however this is not always the case. In some instances slight reductions in speed can vastly improve weld quality over increasing laser power.

### 6.3.2 Fixed Welding Setup and Program Execution

The following is the procedure for setup and execution of a typical **fixed welding program**.

1. Turn on the Rofin Fiber Laser system as per the startup procedure outlined in Section 3.

2. Produce G-code and transfer it to the workstation incorporating the design notes above.

    - SmartCAM instructions for converting a .dxf file from Solidworks to g-code can be found in Section 10.
    - The code generated is based on a **RELATIVE** coordinate system and does not provide an origin. This means that the first command in the G-code generated in SmartCAM is a laser on command. Unless the g-code is modified, the alignment location (position of laser when the program is started) is where the beam will turn on first. **Be aware of this and designate a welding program origin accordingly. When considering the design constraints discussed above however, this is not an issue.**

3. Figure 34) Using the **Manual Motion Page** in Nview, move the **x-y motion table** up front by the workstation door and install your base plate datum or T-groove fixturing.

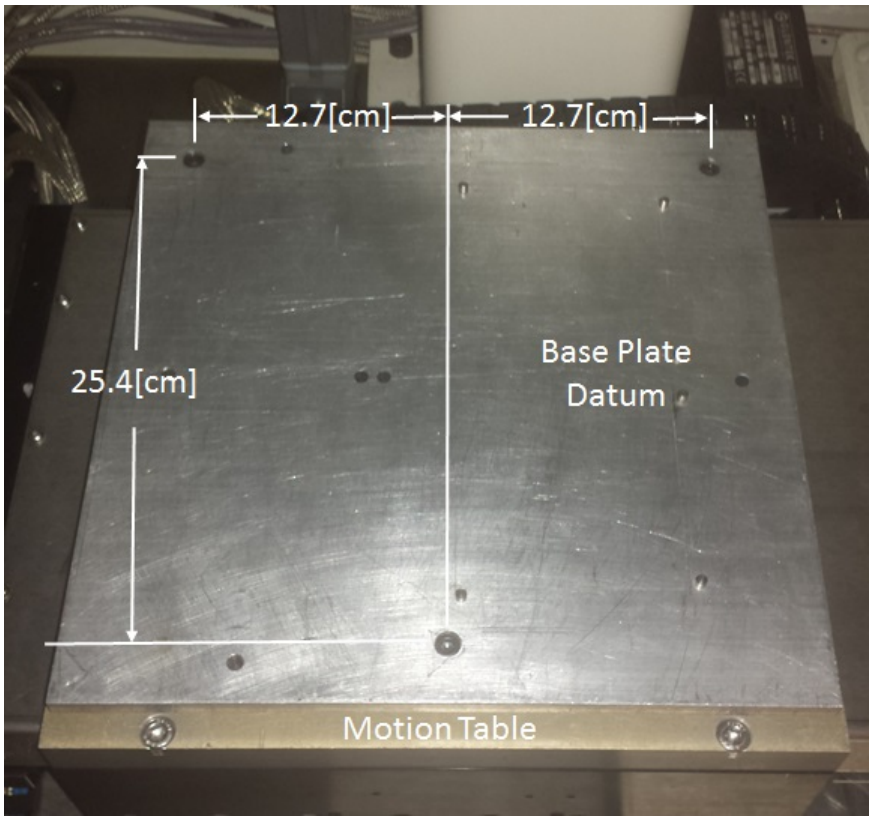



Figure 34: A typical base-plate datum made of 6061 Aluminum used for stainless steel and superalloy welding. Aluminum has a high thermal conductivity which prevents welded parts from sticking to the base plate. **NOTE:**Three holes with a diameter of 0.245[in] are required for mounting a plate on the stage. The bolt pattern is shown.

4. Set the focal distance by the described process in Subsection 6.1 to your reference datum. Offset the distance as needed to find your material focal plane.

5. If needed, check that the base plate datum is square. To do this, align the beam on top of a straight feature on the datum (machined line or base plate datum edge work well) using the HeNe laser and move the table manually back and forth along the feature. Adjust the base plate datum position until the beam and feature align well for long travel distances.

6. Install your samples to be welded, weld plate, and all clamping required. Install your shielding gas setup if needed and route the tube/nozzle so that it will not interfere with work holding during table motion.

7. (Figure 35 Left) Using the HeNe alignment beam, locate the center of the first groove to be welded in. This will dictate one of your starting positions for x or y depending on the groove orientation (horizontal or vertical).
   **NOTE:** For a diagonal weld line, it is best to use an alignment mark that has been designed along with the welding plate. Remember that the HeNe alignment laser has a large spot size so alignment may take a few iterations to get accurate.

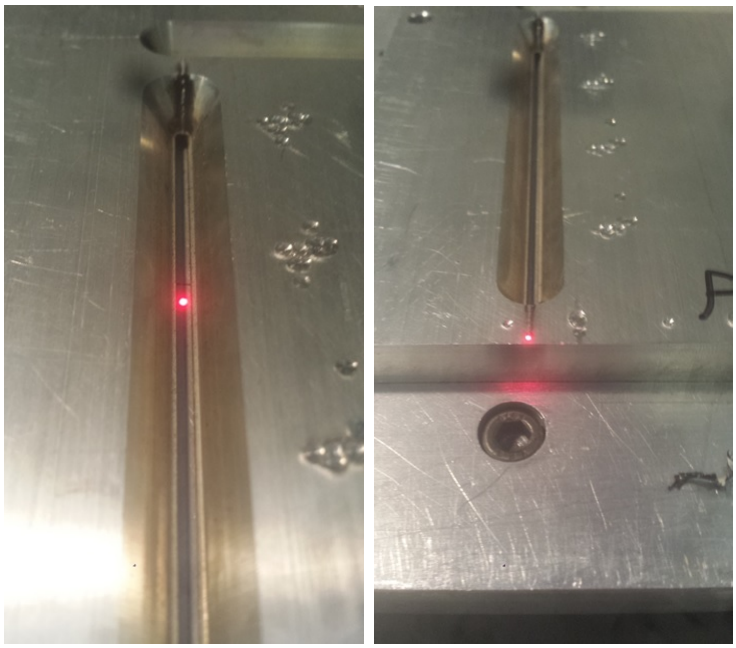


Figure 35: (Left) HeNe alignment laser aligned to the center of a vertical groove on a weld plate. (Right) HeNe alignment laser aligned to the proper overlap for a fixed weld line. Notice the beam is aligned onto the welding plate.

8. (Figure 35 Right) Align the HeNe beam with the designed overlap at the end of the groove.

9. Record the X, Y, and Z positions to add them to the fixed welding program preamble.

10. Load the **blank welding program template** into NView.

11. Save the program under a new name within your user folder within the **Current Users** folder on the computer desktop.
    **!!DO NOT SAVE OVER THE TEMPLATE DOCUMENT!!!**

    **NOTE:** All program names are automatically converted to ALL CAPS.

12. (Figure 29) Modify the program preamble variable values:

```
;----------------------------------------VARIABLE PREAMBLE-----------------------------------
DVAR $size                                          ;Example of a new variable definiti
$size = 20                                          ;Example of assigning a value to th
laserPower = 150                                    ;Set laser power here (50-1000[W])
minPowerRampPerc = 10                               ;Set the starting and finishing per
$zFocusPos=-259.37                                  ;Z Focus position for reference (0-
ThresholdSoftCW.Z=-289.0                            ;Z soft limit
$initXpos= $STATUS[_PositionUnits].X                ;Initial X position for program (Ei
$initYpos= $STATUS[_PositionUnits].Y                ;Initial Y position for program (Ei
$positionSpd=150                                    ;positioning speed (mm/s)   ( 0 to 2
Spd=100                                             ;Processing Speed (mm/s)    ( 0 to 2
$partsToCut=1                                       ;how many times to repeat complete
$piercePrgmNum=7                                    ;program selection for cutting pier
PrgmNum=7                                           ;Laser program selection. PROGRAM 7
```

Figure 36: Variable Preamble section of a fixed welding program.

(a) Modify the value of **laserpower** to correspond to your desired weld power.

(b) Modify the value of **minPowerRampPerc** to correspond to the minimum percent of specifed power for the power ramp function.

(c) Modify the value of **$zFocusPos** to correspond to the recorded Z-position from step 7.

(d) If desired, modify the value of **$initXpos** to correspond to the recorded X-position from step 7. Otherwise the default value ($STATUS[_PositionUnits].X) will start the program from the current location.

(e) If desired, modify the value of **$initYpos** to correspond to the recorded Y-position from step 7. Otherwise the default value ($STATUS[_PositionUnits].Y) will start the program from the current location.

(f) Modify the value of **Spd** to correspond to the required welding speed given by your weld design.

(g) Ensure the value of **PrgmNum** is set to **7**.

13. Open the G-code generated for the part in Notepad and copy the code into the program in NView within the **MOTION CONTROL** program section.
**NOTE:** The template includes repeat loops and sub-routine callouts to use if needed. SmartCAM does not use these, so if desired you must incorporate them into your code now. Often it is also desired to allow the work piece to cool down between welds, so if multiple welds are performed in a single program execution, **DWELL** commands can be added. The units of this command are seconds.

14. Load the program into **TASK 1** by doing the following:

    (a) Select **SAVE**.

    (b) Select **CHECK**. This will compile your program and display any errors or warnings encountered in the **messages** window above the **F2 option bar**. Fix any errors if present. Some warnings can be ignored.

    (c) Select **RUN**. This will load your program under **TASK 1** and automatically navigate you to the **RUN** page in NView.

15. Modify the **laser source internal program 7** according to your cutting recipe.

16. Validate program motion through a **DRY-RUN** by doing the following:

    (a) Navigate to the second options menu on the **F7 options panel** and select **F̂10 Dryrun Mode**, which will turn yellow after selection.

    (b) Select **TASK 1** from the tabs on the left side of the run screen. verify that the appropriate program has been loaded and verify the starting position in the code preamble matches the current position readout on the top of the screen. If they mismatch, the machine will automatically move to the specified coordinates in the program when the program is started.

    (c) Check for any obstructions within the workstation that could hinder correct table motion or that could crash into the galvo cross jet. Fix any suspected issues.

    (d) Select **F2 Cycle Start** from the **F2 Options Panel**. The table position will now adjust to match the starting position called out in the program.

(e) The code line **M0 ;Wait for cycle start button** will be highlighted and acts as a prompt to select **F2 Cycle Start** to start the welding program. **At this point it is important to pay full attention to the workstation and be ready to stop the program if issues arise**.

(f) The program will now execute. Monitor table motion and ensure proper code execution. If unexpected table motion occurs select the **F4 ABORT** button. The **F4** button will change to be a **Reset** button. Press this to reset the program. After an abort, all gasses activated and must be turned off manually or by restarting the program. **IF ANY ISSUES OTHER THAN TABLE MOTION OCCUR PRESS THE E-STOP BUTTON IMMEDIATELY AND CONTACT MBI STAFF TO RESET THE SYSTEM.**

17. Based on the results of the dry run, make modifications to the program code and perform a second dry run if needed. If table motion was good, proceed to the next step. **NOTE:** After any program is fully executed, the three axes will need to be initialized if any manual table motion is performed. There is no need to re-initialize if the program will just be re-ran without any manual motion performed.

18. Turn on the fume extractor (Section 3 Item 3) if it is not currently running. An error will occur if the extractor is not turned on during final laser firing.

19. Run the validated program by following the following steps:

    (a) Deselect the **Dryrun Mode** button. The button color should return to grey.

    (b) turn the **LASER** key on the workstation front control panel to the **ENABLE** position if it has not already been done.
    **!!THE LASER IS NOW ENABLED AND WILL FIRE DURING THE NEXT PROGRAM RUN!!**

    (c) Select **F2 Cycle Start** from the **F2 Options Panel**. The table position will now adjust to match the starting position called out in the program.

    (d) The code line **M0 ;Wait for cycle start button** will be highlighted and acts as a prompt to select **F2 Cycle Start** to start the welding program. **At this point it is important to pay full attention to the workstation and be ready to stop the program if issues arise**. **NOTE:** After the program starts, the **messages** screen will be displayed ad will provide any warnings or fault messages during execution. Typically the only messages displayed during proper program execution are **Laser Ready** and **Laser On**. If any minor faults occur, typically the laser will not fire and the table motion will pause. If this happens, it is often possible to resolve the issue and clear the fault without restarting the program, at which point the program execution will resume.

20. After program completion, remove the clamping and weld plate, and inspect the welded parts.

21. Perform any additional welds required. As the workholding described here is typically designed for a specific weld, if multiple, identical parts are to be welded it is often easier to execute the same program on the new parts before changing the workholding for the next weld.

    After all welding is completed:

22. Remove the **shielding gas setup, workholding, and base plate datum** from the system.

23. Home all axes.

24. If no user is waiting to use the tool, shut down the system following the shutdown procedure found in Section 4. If a user is waiting to use the tool, reset the system in NView.

## 6.4 Shielding Gas Installation and Use Procedure

This section covers the details on how to add shielding gas to your welding process. There are many options available in terms of nozzles, tubes, gasses, and routing, so a generic setup will be described here.

1. Safely install the gas cylinder to the left of the workstation and install a pressure regulator on the cylinder outlet. Th outlet of the regulator should have a long length of 1/4 inch OD tubing to connect to the press-fit air fitting.

2. Connect the tube to the rear of the workstation in the **Shield Gas** labeled inlet.

3. Control the gas pressure using the pressure regulator on the cylinder.

4. (Figure 21) Turn on and off the shield gas using the **F9 Shield Gas** button on the F7 options menu in **NView**.

# 7 Laser Source Pendent Operation

This section covers the basics of changing the laser operating mode and modifying laser program parameters.

## 7.1 The Menu Screen


Figure 37: The Menu screen is the main navigation screen on the pendent and is the first to display after login. It provides simple details about the program mode, active program, and laser status. This screen also provides a real-time readout of laser power when the beam is on.

## 7.2 Status Screen


Figure 38: This screen provides an overview of the laser status and will help in troubleshooting errors and faults. This is also the screen where a user can **enable master**, the first step in changing the **program mode**.

## 7.3 Program Modification

This section covers how to change the laser program parameters of pulse programs on the laser source.

1. (Figure 39) From the **Menu** screen, navigate to the **Programs** screen by selecting **Prog.**.


Figure 39: This screen provides an overview of the active program selected and allows one to access the pulse and ramp program lists. The upper-left box displays the current **Operation mode**.

2. (Figure 40, 41, 42, 43) Select **Pulses**. This will navigate to the **Pulse Program List**. Select the program you wish to edit by double-tapping the program.


Figure 40: This screen provides an overview of all pulse programs available.


Figure 41: This screen shows all program parameters. To edit a parameter, select **Edit**. fields that can be changed will be highlighted in orange. To cancel changes, select **Cancel**.


Figure 42: Select the field you wish to edit by taping on the highlighted field. For applicable fields, a pop-up window will appear with a touch keyboard.


Figure 43: In the pop-up window Type in the desired value for that field and select **Ok**. **IMPORTANT: NO CHANGES ARE MADE TO THE PROGRAM VALUES UNTIL "SUBMIT" IS SELECTED!!**. To cancel changes, select **Cancel**.

## 7.4 Changing Operating Mode

This subsection covers how to change the operating mode of the fiber laser source between **VLM** and **Internal Programs**.

1. (Figure 44) To **enable master**, navigate to the **status** screen and select the double-arrow button to reveal additional options. Select the **master** button. The status box next to the **Master** line on the screen will turn green.


Figure 44: The additional options on the **status screen** that are revealed after selecting the **double-right arrow** button.

2. (Figure 39) Navigate to the **Programs Page** and select the **Edit** button. Options or values that can be changed will be highlighted.
3. Select the operating mode you desire by taping on the bullet next to it.
4. Select the **Submit** button to finalize the change.

## 7.5 Clearing an Error

This subsection covers how to see and clear an error on the laser source pendant. If an error remains on the status page after attempts to clear, seek help from a lab technician.

1. (Figure 38) Navigate to the **Status Screen** and select **Errors** to view a list of currently active warnings and errors.

2. Select **clear** to clear any errors or warnings present. If an error is not removed from the list, than the fault has not properly been cleared. Try to clear the fault again. If the error is persistent, contact a trained lab technician.

## 7.6 Manual Mode Operation

This subsection covers how to fire the fiber laser in manual mode. This mode is primarily used by technicians, so the procedure here assumes proficient use of the Rofin system in its entirety and references many different sections in this manual. The source program mode must be in **Internal Programs**. Figure 45 outlines the pertinent features of the pendent needed for this procedure. Most steps refer to this figure.

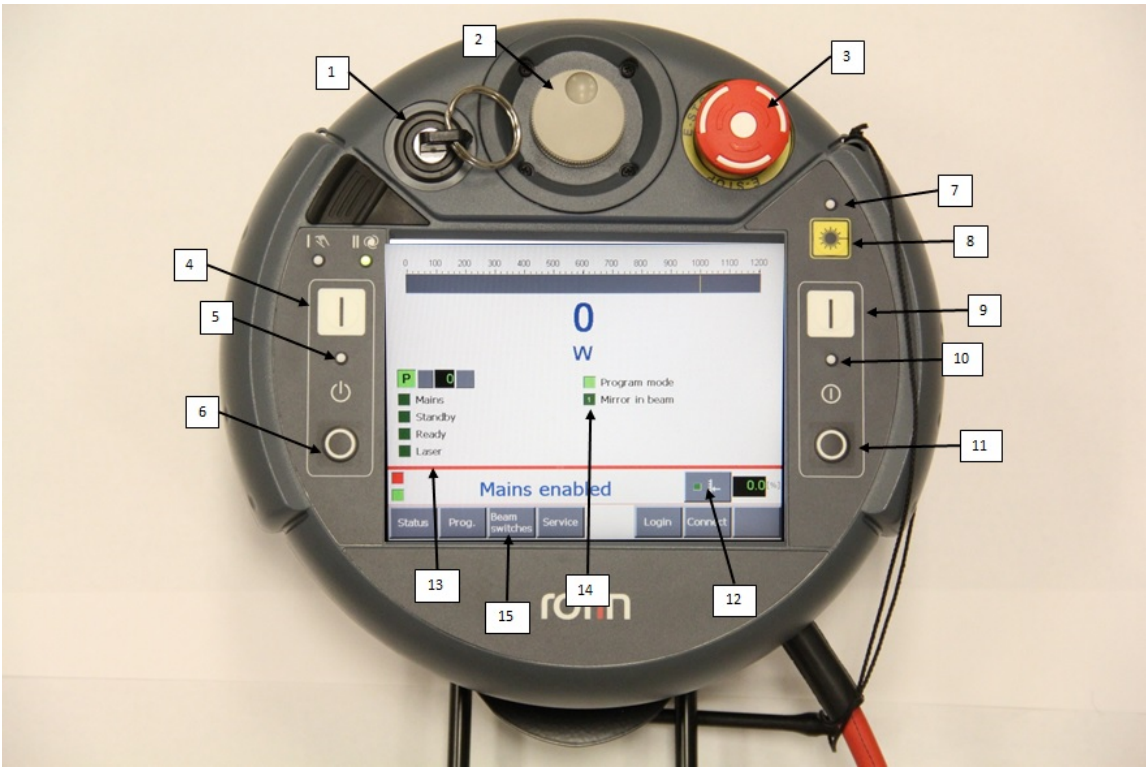



Figure 45: Pendent features for manual mode operation

1. Laser source control key
2. Control dial (for selected variable control)
3. Emergency stop button (E-Stop)
4. **LASER MAINS ON** button
5. **LASER MAINS** indicator light
6. **LASER MAINS OFF** button
7. **LASER ON** indicator light
8. **LASER ON/OFF** button
9. **LASER STANDBY ON** button
10. **LASER STANDBY** indicator light
11. **LASER STANDBY OFF** button
12. Enable variable power control. Allows use of the control dial (2) to variably control laser power.
13. Source status indicators and program select buttons. The various boxes will be lit green when activated.
14. **Mirror in Beam** indicator. (green indicates mirror in beam)
15. **Beam Switches** button to access the Beam Switches menu.

**To fire the beam manually, do the following:**

1. (Figure 45 #1) Turn the laser source control key **clockwise** to put the source in manual mode.
2. (Figure 45 #4, #5, #13) When the pendent reads **mains enabled** press the **LASER MAINS ON** button. Both the mains indicator light and the source status indicator for Mains will turn green.
3. (Figure 45 #9, #10, #13) The screen will read **cooling start** for 30 seconds, then it will read **standby enabled**. Once this message is displayed, press the **LASER STANDBY ON** button. Both the standby indicator light and the source status indicator for Standby will turn green and the red status lights on top of the source and workstation turn on.
4. (Figure 21) In the NView software, select the **System OK** button.
5. (Figure 8) On the workstation front control panel and turn the **LASER** switch to **ENABLE**.

6. (Figure 45 #14, #15, Figure 46) Navigate to the **Beam Switches** page. If the door is closed and the pendent reads **Laser Enabled**, you can now aim the beam down the process fiber by selecting the **fiber select** button. The **HeNe** button switches on the red aiming laser. Whenever the door is opened, the fiber select button will need to be re-selected. On the Menu screen, the **Mirror In Beam** status light will turn green.


Figure 46: The Beam Switches page on the laser source pendent. 1. **Laser Select** button, 2. **HeNe Laser** button.

## THE LASER IS NOW READY TO FIRE

7. (Figure 45 #13) Using the up and down arrows on the **Menu** screen, select the program you wish to use.

8. (Figure 45 #2, #12) To use variable power, the program must have **Pulse Scaling** set to **L**. To enable variable power, select the **Variable Power Control** button on the menu screen. The power percentage readout next to the button will turn yellow showing it can be edited. Either use the dial to modify the power scale, or tap the readout and enter a power using the pop-up window. This is only enabled for a short time, so be sure to check it during operation.

9. (Figure 45 #7, #8) To fire the laser, press the **LASER ON** button. The indicator light will turn yellow. If the beam has not been aimed down the fiber, the laser will fire into the beam dump within the source. The **Fiber Select** button can be selected while the beam is firing.

10. (Figure 45 #7, #8) Press the **LASER ON** button again to stop firing the laser. The indicator light will turn off when beam is turned off.

# 8 NView Basics

This section covers the basic navigation and most used commands in the NView software. More detailed information and instructions can be found within the NView help.

There are 4 pages in NView that are used regularly. These are:

- Home Page (Figure 47) Used for navigation and resetting the workstation.
- Run Page (Figure 48) Used to control and execute a program.
- Manual Page (Figure 50) Used to manually move the x, y, and z axes.
- File Page (Figure 51) Used to load, modify, and initialize a program.

## 8.1 Home Page

The **Home Page** is often used only for navigating between various screens. The two options panels shown change depending on the screen active.

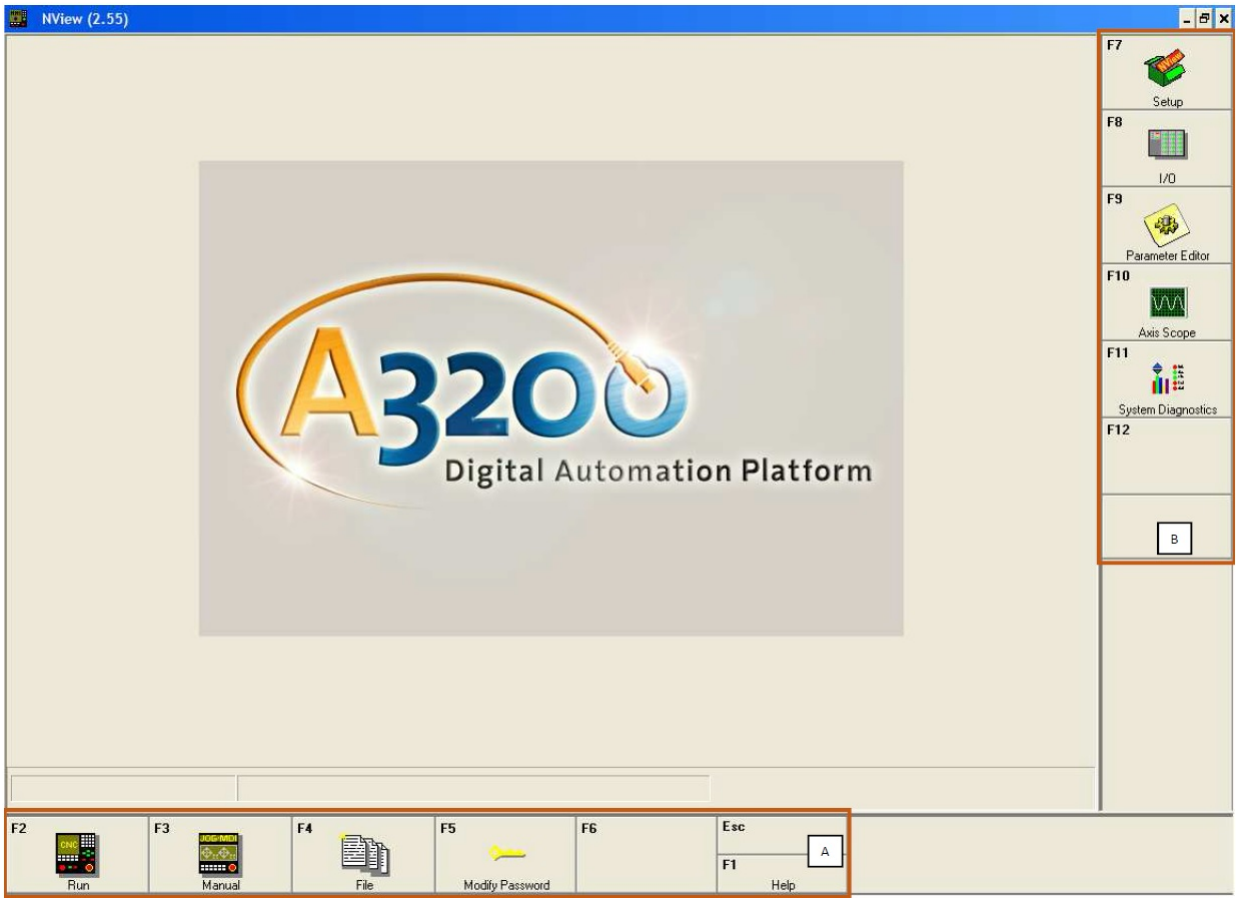



Figure 47: NView Home Page.

This screen is often used only for navigating between various screens. The two options panels shown change depending on the screen active.

A. F2 options menu

B. F7 options menu

## 8.2 Run Page

The **Run Page** is used to execute coded programs.

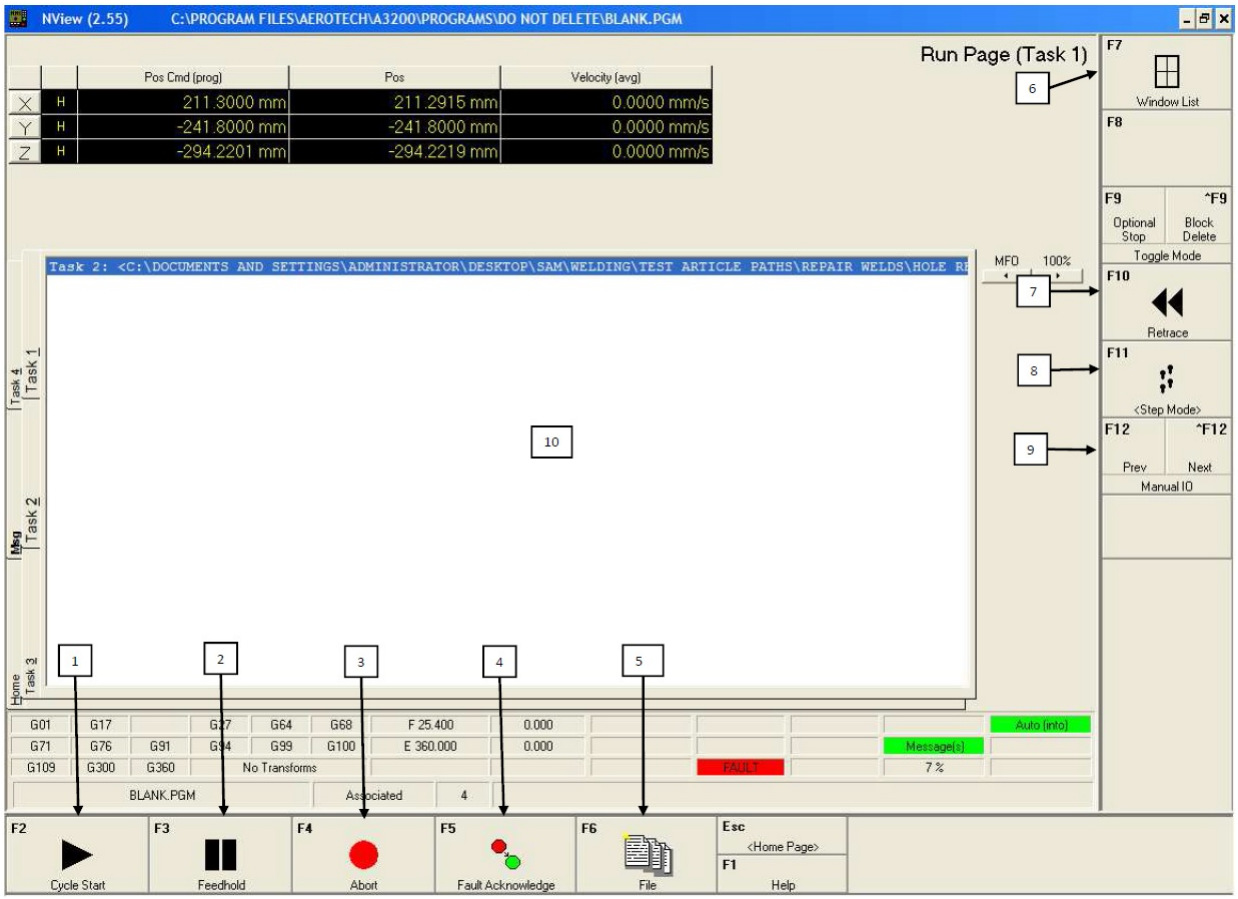



Figure 48: NView Run Page.

1. The **F2 Cycle Start** button runs the active program. Once pressed to execute a program, this button changes to a **stop** button. If the stop button is pressed, the current active command in the program will finish execution and then the program will stop.

2. The **F3 Feedhold** button stops table motion at it's current location. Press once to stop motion and the button will change to a **Release** button. Press this to release and continue table motion. **If the laser is on, it will remain on during feedhold.**

3. The **F4 Abort** button aborts the current program during exection. Table motion is stopped and the laser is turned off. **This button is the primary way to stop a program if an issue occurs! If something is going wrong, PRESS THIS FIRST!!**. Once pressed, this button is replaced by a **Reset** button that resets the corrent program to the first line of code.

4. The **F5 Fault Acknowledge** button is present on most screens and clears faults if they are present and clearable. If a fault occurs and this button does not clear the fault, seek help from a trained lab technician.

5. The **F6 File** button navigates to the **File Page**.

6. The **F7 Window List** button pops up a list from which windows can be easily selected and navigated to.

7. The **F10 Retrace** button selects the program motion. When selected the G-code will be executed in reverse order and the button will change to read **Forward**.

8. The **F11 <Step Mode>** button, when selected, executes the G-code one line at a time. The **F2 Cycle Start** button is pressed after each code execution. This button text changes to read **sflksjdflkjsdf** upon clicking.

9. The **F12 and F̂12** buttons navigate the F7 options menu to the previous and next screens respectively. The ˆ denotes the need to press the shift key along with the hotkey designation.

10. The **Active Program** window shows the program active on the selected task. The tabs of the left of this window allow navigation between the various tasks. During a live run of a program, the **Message Tab (Msg)** is shown automatically to allow monitoring.

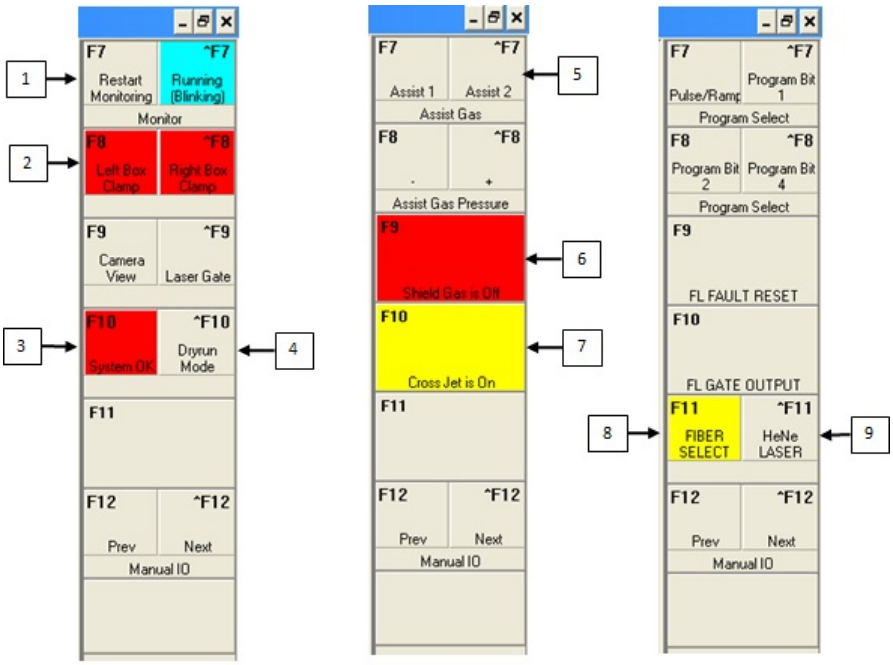



Figure 49: Additional F7 options menus available by navigating with the **F12 and F̂12 buttons.**

1. The **F7 and F̂7** buttons control system monitoring. The **F̂7 Running** button should always be blinking cyan.

2. The **F8 and F̂8 Clamp Control** buttons control the left and right pneumatic clamps on the cutting box. Their color indicates whether the clamp is active or not, and switches between red for inactive and green for active. The clamps are automatically activated when the **F2 Cycle Start** button is pressed for a cutting program if they have not been manually activated.

3. The **F10 System OK** button is an interlock button that automatically turns on (the button color will turn green) during NView program exectution if the system is in working order. It needs to be manually selected for welding using the **VLM** software.

4. The **F̂10 Dryrun Mode** button enables the Dryrun Mode for NView programs. The button color will turn yellow when Dryrun Mode is active.

5. The **F7 and F̂7 Assist Gas** buttons control the flow of the two available assist gasses. The button color will turn yellow when active.

6. The **F9 Shield Gas is ___** button indicates and controls the status of the shielding gas. Button color will turn to yellow and the text will change to read **Shield Gas is On** when gas is flowing.

7. The **F10 Cross Jet is ___** button indicates and controls the status of the galvo head cross jet air flow. Button color will turn to yellow and the text will change to read **Cross Jet is On** when air is flowing.

8. The **F11 FIBER SELECT** button controls the laser source beam switch and automatically activates during the execution of an NView. This button mst be manually selected for welding using the **VLM** software. When the fiber is selected, the button color will turn to yellow.

9. The **F̂11 HeNe LASER** button controls the red Helium Neon aiming and alignment laser. The button color will turn to yellow when the HeNe laser is turned on.

## 8.3 Manual Page

The **Manual Page** is used to manually move the three axes available on this Rofin at the MBI. The A-axis shown is reserved for rotation control if a rotation motion controller is ever installed in the system. While the button is available to be selected, the **F2 Cycle Start** button is inactive on this page.

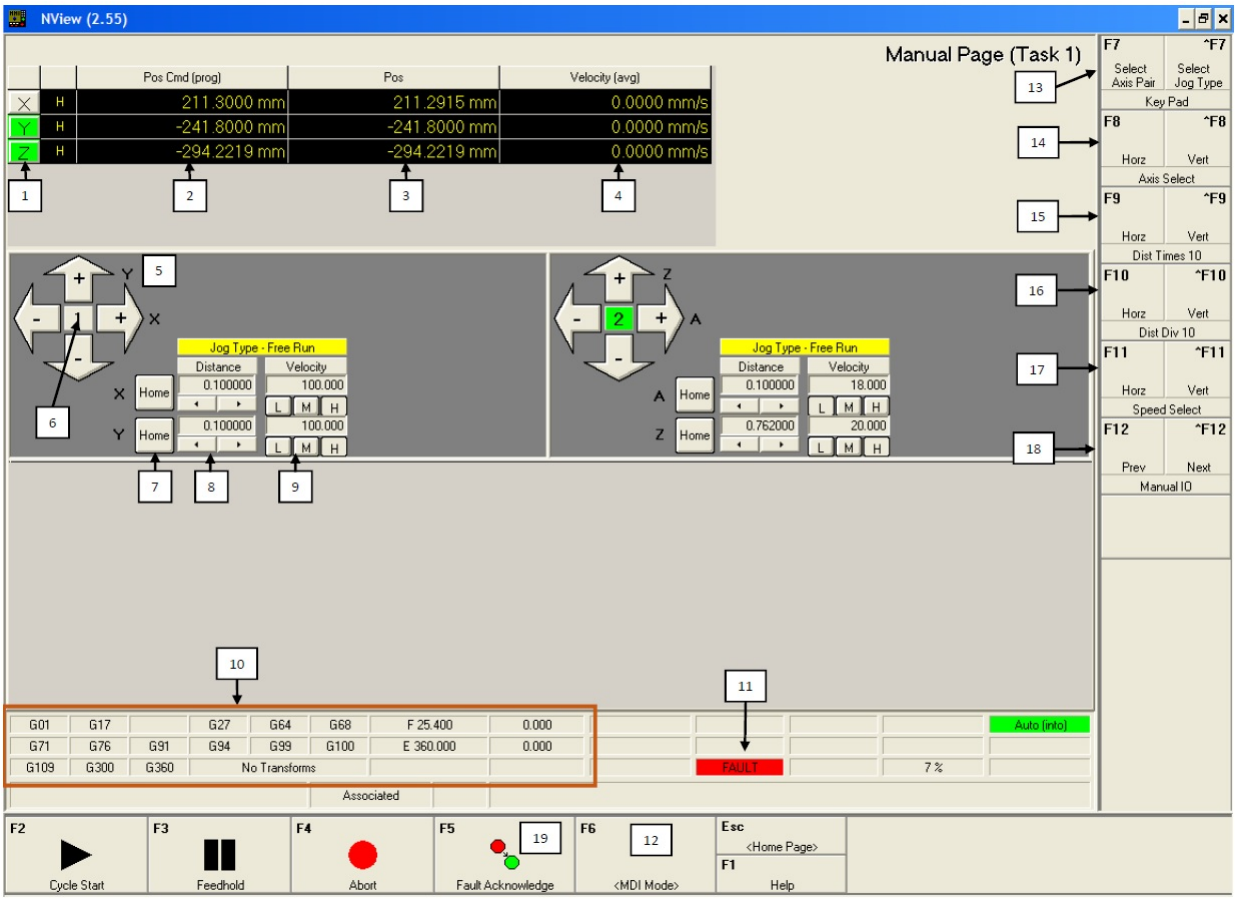



Figure 50: NView Manual Page.

1. **Axes indicator buttons.** These three buttons display whether the axes is active or not by changing to green when the axes is active. To initialize(activate) a axes, press the corresponding button for that axis.

2. **Position Command readout.** This area shows the specified location the axes has been told to move to.

3. **Actual Position Readout.** This area shows the actual position of the three axes. If the actual and command readouts do not match, a fault will occur. re-activate the axes and clear the fault.

4. **Velocity Readout.** This area shows the current average axes motion velocity.

5. **Axes Motion Control Arrows.** These sets of arrows (for x-y and z-a motion) control the axes motion for the two available directions for each axes. The keyboard arrow keys control these buttons for the active axes pair. **NOTE: Pressing an arrow for the A axes will result in a fault.**

6. **Axis Pair Selection.** The center button within the arrow keys selects that axis pair for motion. These buttons are used to select the axis pair to be controlled by the keyboard arrows. Pressing a motion control button will automatically select that axis pair. The selected axis pair can also be changed using the **F7 Select Axes Pair (13)** button.

7. **Axes Home Buttons.** These buttons home the specific axes as desired. **IF HOMING MULTIPLE AXES, ALWAYS HOME THE Z-AXES FIRST TO PREVENT POTENTIAL OPTICS HEAD IMPACTS!!**

8. **Distance Control and Jog Type.** These input boxes are used to control the motion distances for **Distancehold and Distance** jog type motion. Enter any number, or use the arrows to change the position of the decimal point in the number already present. To cycle the jog type between the three options (**Free Run, Distance(hold), or Distance**), either double click the yellow **Jog Type button** or select the **F̂7 Select Jog Type (13) button.**

9. **Axes Velocity Control.** Control the velocity of axes motion by entering in a value or selecting from the **Low Speed (L), Medium Speed(M) or High Speed(H)** buttons.

10. **G-Code Active Display.** This display shows any active G-code commands that are currently attempting to control axes motion.

11. **FAULT Indicator.** This box will be red and read **FAULT** if a fault in the system is present. Once the fault is cleared, this indicator will be blank.

12. **<MDI Mode>.** This button enables MDI mode and allows the user to use G-code commands to control axes motion.

13. **F7 and F̂7** These two buttons are additional ways to select the axis pair or change the jog type.

14. **F8 and F̂8 Key Pad Options.** These two buttons switch between horizontal and vertical motion for the keyboard arrow keys.

15. **F9 and F̂9 Axis Select Options.** These two buttons control which axis of the axis pair are active.

16. **F10 and F̂10 Distance Times 10.** These buttons increase the travel distance by a factor of 10 for the selected axis (horizontal or vertial).

17. **F11 and F̂11 Distance Divided by 10.** These buttons decrease the travel distance by a factor of 10 for the selected axis (horizontal or vertial).

18. **F12 and F̂12 Speed Select.** These buttons cycle through the low, medium, and high speeds for the selected axis.

19. **F5 Fault Acknowledge.** This button acknowledges and attempts to reset a fault when encountered.

## 8.4 File Page

The **File Page** is used to load, modify, and "run" a motion and laser control program. Use the NView Help program to review the specific commands used in a cutting or fixed welding program.

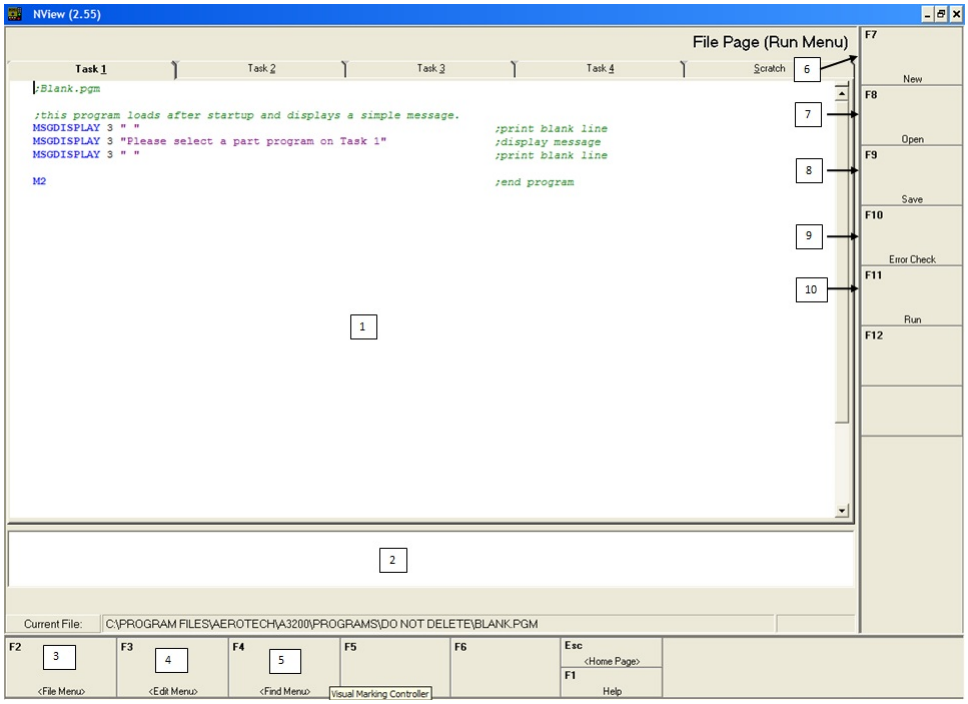



Figure 51: NView File Page.

1. The **Program Display Window** shows the active program. Executable commands are blue, command options are magenta, and comments are green.

2. The **Message Display** shows any messages that occur while working on the File Page.

3. The **F2 <File Menu>** button changes the **F7 Options Menu** to a list of options to modify the file. The only button that changes is the **F10 Error Check** button, which becomes **F10 Save As**. Once this button is selected, it will be replaced with a button labeled **<Run Menu>**, which when selected will display the menu options shown in the figure above.

4. The **F3 <Edit Menu>** button changes the **F7 Options Menu** to a list of options to help simplify modifications to the program code. Options like **Copy and Paste** are available in this menu. Once this button is selected, it will be replaced with a button labeled **<Run Menu>**, which when selected will display the menu options shown in the figure above.

5. The **F4 <Find Menu>** button changes the **F7 Options Menu** to a list of options to help simplify modifications to the program code. Options like **Find and Replace** are available in this menu. Once this button is selected, it will be replaced with a button labeled **<Run Menu>**, which when selected will display the menu options shown in the figure above.

6. The **F7 New** button will open a blank program.

7. The **F8 Open** button will open a selection window to load a saved program.

8. The **F9 Save** button saves the current program.

9. The **F10 Error Check** button compiles the active program and displays any errors or warnings in the **Message Display Window(2)**.

10. The **F11 Run** button loads the current program into **task 2** and navigates to the **Run Page** to allow the program to be executed.

## 8.5 Workstation Reset Procedure

Sometimes to properly fix a fault or motion issue, or when the operating mode is to be changed, the motion controller needs to be reset. Follow these simple steps to reset the motion controller.

1. Navigate to the **Home Page**

2. (Figure 52) Select the **F7 Setup** button to navigate to the **setup Page**.

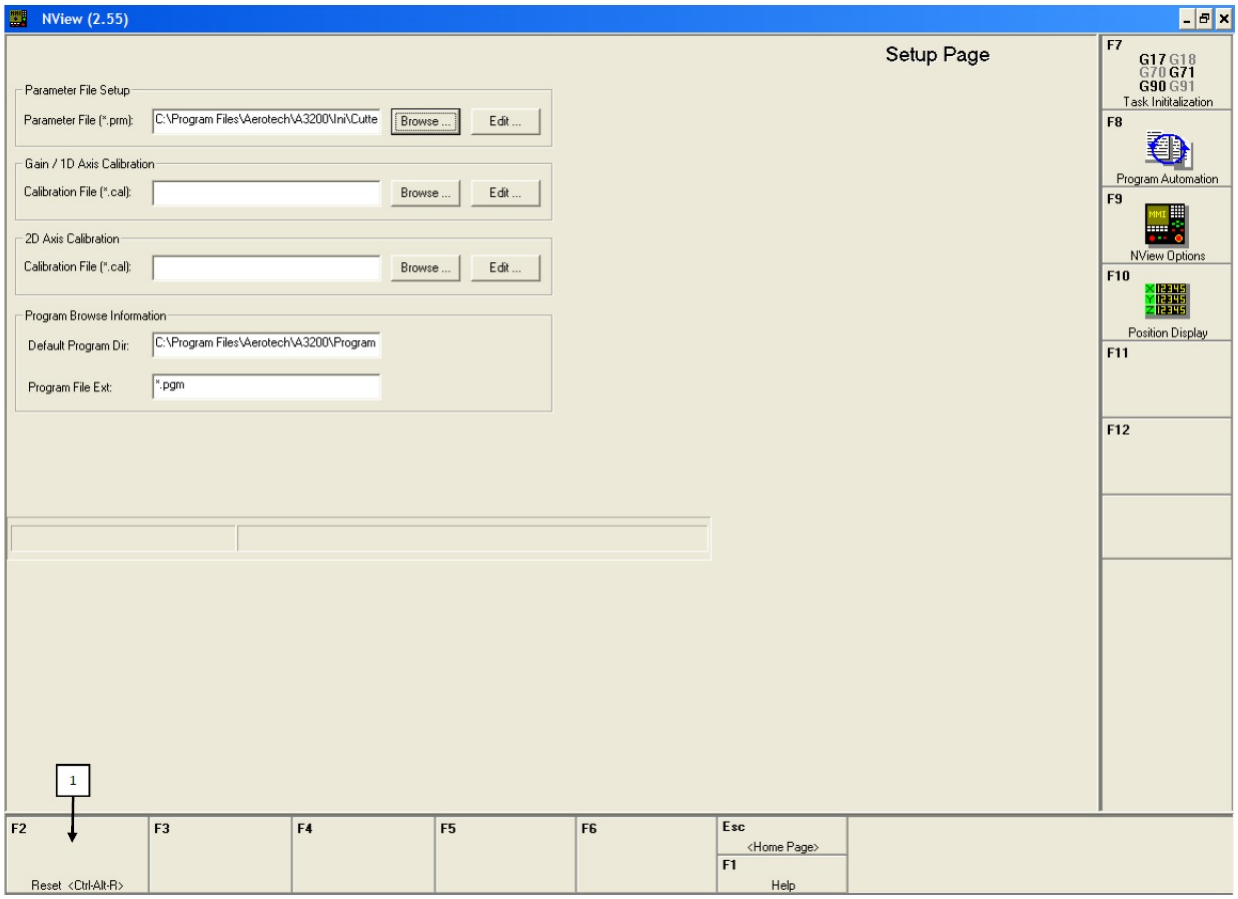



Figure 52: The NView Setup Page.

3. (Figure 52) Press the **F2 Reset** button. When the system has been reset, a status window in the middle of this screen will read **Reset OK**.

4. Navigate to the **Run Page** and select your operating mode according to the steps outlined in the start-up procedure in Section 3.

# 9 Visual Laser Marker Basics

This section covers the basic navigation and properties of the Visual Laser Marker (VLM) software. Detailed information on the software package can be found in the VLM User Manual, located on the desktop of the Rofin computer. The VLM User Manual is very detailed and should be able to answer any questions that arise during use.

## 9.1 VLM Basic Use

Figure 53 provides an overview of the VLM user interface. The software is essentially a CAD package that allows individual elements to be drawn and assigned individual laser parameters, or .dxf files can be imported and assigned laser parameters for the entire .dxf file.

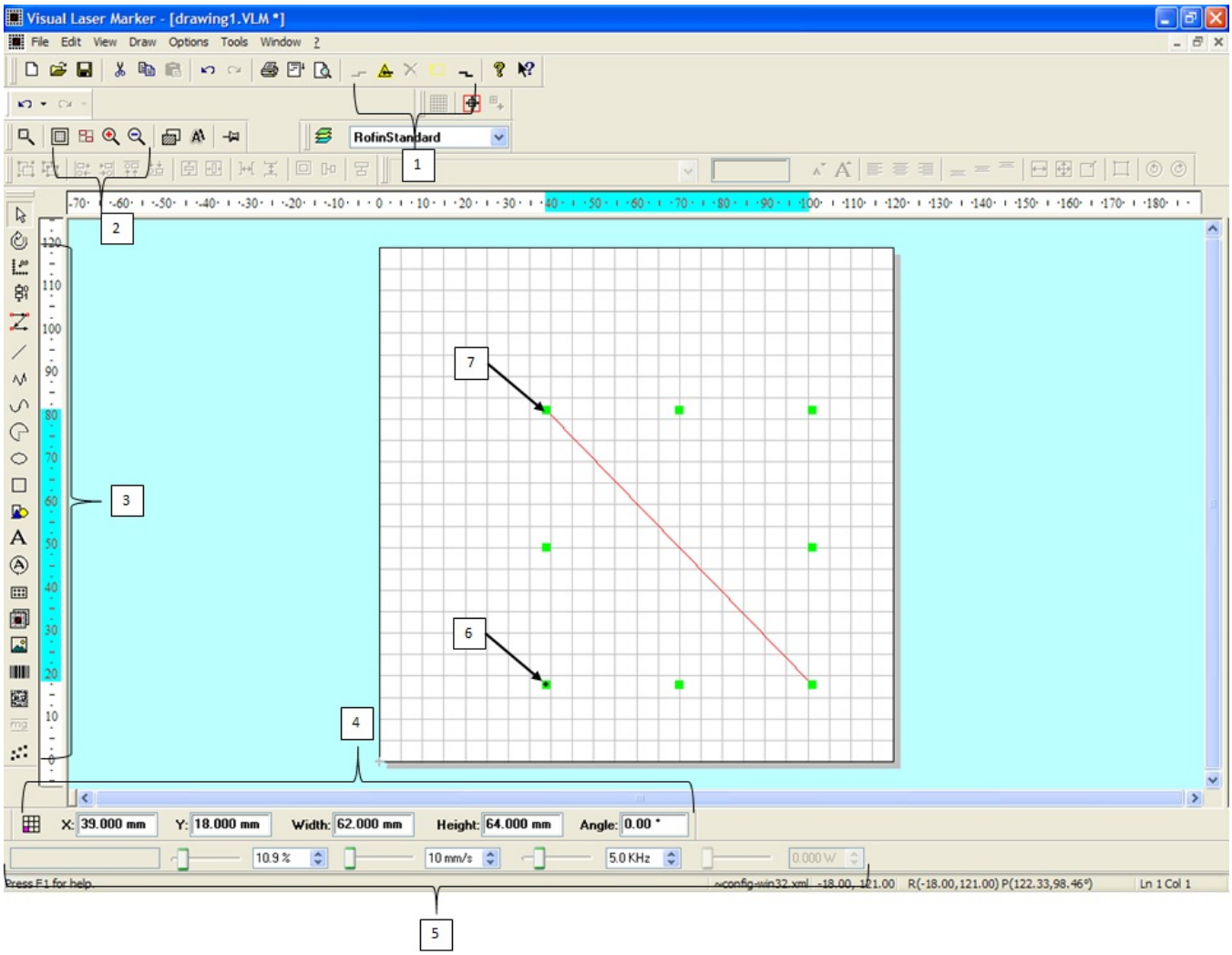



Figure 53: VLM User Interface Basics. Descriptions of the numbered elements are in the following list.

1. **Program Execution Toolbar**. Buttons from left to right:
    - Initialize Hardware
    - Execute program
    - Cancel execution
    - asdlkjasdflk
    - disconnect hardware
2. **View Toolbar**. Buttons from left to right:
    - Zoom Full
    - Zoom to Marking Area
    - Zoom In
    - Zoom Out
3. **Drawing elements and element control options**. Top buttons allow automatic or manual selection of the element execution order. Various drawing elements are lines, splines, circles, rectangles, text. Barcodes and QR codes can also be marked.
4. **Element location control**. Buttons from left to right:
    - Reference Location (click repeatedly to select)
    - X-position. 60[mm] is center of drawing.
    - Y-position. 60[mm] is center of drawing.
    - Element width.
    - Element height.
    - Element rotation angle.
5. **Laser parameter controls**. These options are active when the selected drawing element has the laser type set to **Individual LP Set** and control program number, power, speed, frequency, and scale.
6. **Reference Location**. A black dot on one of the green alignment marks shows active reference location.
7. **Line element**.

## 9.2 VLM Drawing Element Properties

Figure 54 shows 5 useful properties tabs that are accessed by double-clicking on an element. These 5 tabs are the most used tabs. For details on additional tabs and options, refer to the VLM User Manual. Some tabs, for example text properties, are only available for the relevant element type.

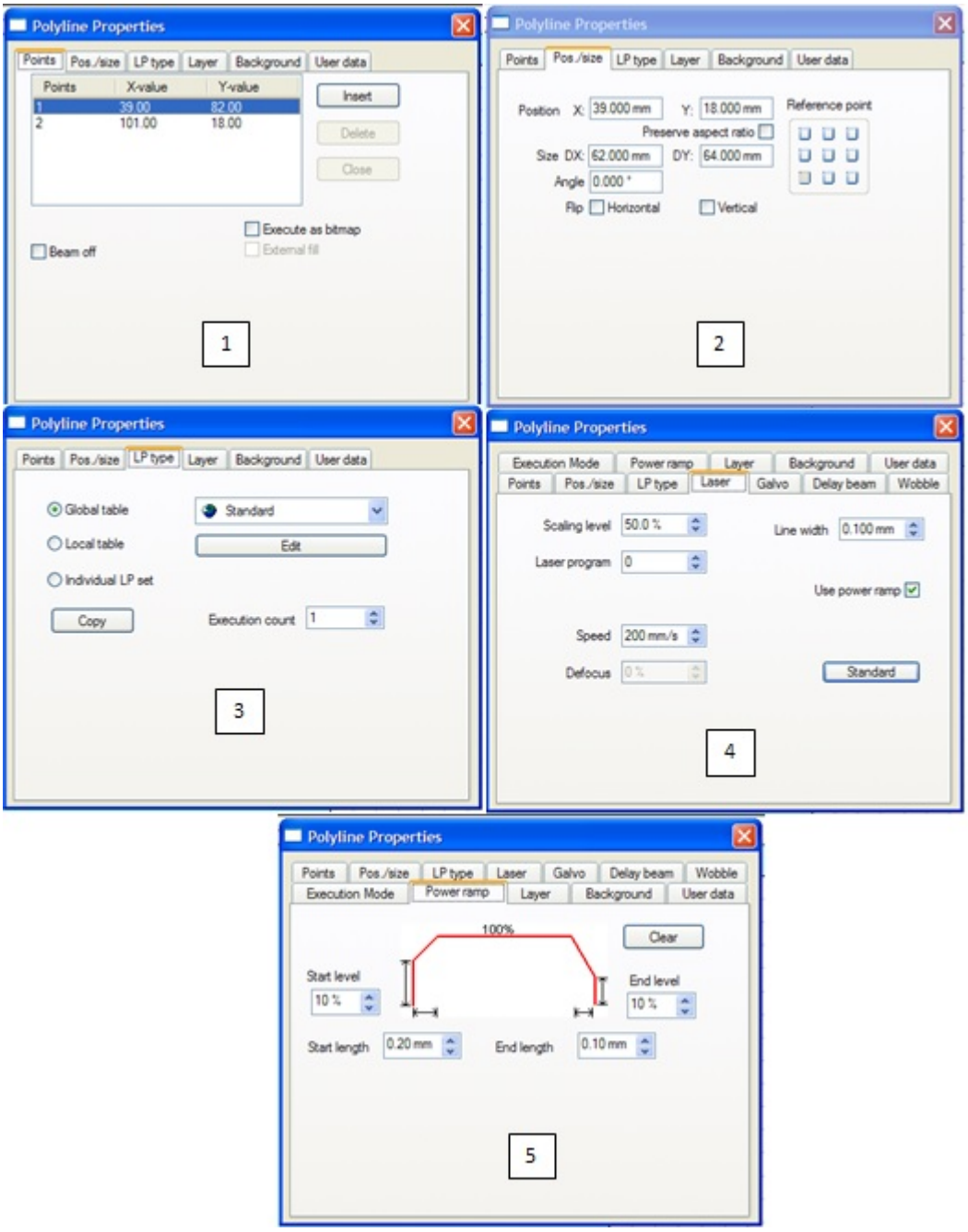



Figure 54: 5 useful properties pages for a drawing element. Access these properties by double-clicking on the drawing element you wish to change to properties of.

1. **Points Properties Tab**. This Tab is one method to control the

size and location of an element.

2. **Position Properties Tab**. This tab is an additional method to control the size and location of an element.

3. **LP Type Tab**. This tab is how a user selects the laser parameter control method. Either laser parameters can be assigned from a **Global Table** which has been built into the software by past users, a **Local Table** which is a table of parameters set up by a user for a specific drawing, or **Individual LP Set** which allows a user to set laser parameters for each element individually. Global tables are accessible in any drawing and are used for things like steel marking or Nickel Superalloy welding of a specific thickness type. Local tables are built within a drawing and are useful for complex drawings.

4. **Laser Properties Tab**. This tab is available when the Laser Program Type is set to **Individual LP Type** and controls the basic laser parameters. An important note is laser program number 8 is the one reserved for VLM control. **always use program number 8**. Line width is not controlled by VLM and is a function of focus, speed, and power. The **Use Power Ramp** check box enables a power ramp for that given element and a new properties tab, **Power RamP** will show up.

5. **Power Ramp Tab**. This tab controls the power ramp profile of the laser beam when fired. To activate power ramp, select the check box for **power ramp** on the **Laser Properties Tab**.

# 10 Rofin Specific SmartCAM Instructions

Many CNC (computer numeric control) tools use G-code, a set of text commands, to describe the sequence of movements necessary to fabricate a part. This document provides step-by-step instructions to generate G-code for the ROFIN starting with a SolidWorks part.

## 10.1 File Setup

In order to import a SolidWorks part into SmartCAMv15 the file should be a 2D drawing in .dxf format with dimensions in millimeters. To do this, follow these steps:

1. Open the desired part file in SolidWorks
2. Ensure the desired view is displayed (Top, Right, Front,...).
3. Select "File" then "Make Drawing from Part"
4. In the "Sheet Format/Size" dialog box, uncheck "Display sheet format" and click "OK"
5. Left click "Model View" in the "View Layout" tab near the top left corner.
6. Verify that the desired document is highlighted in the "Part/Assembly to Insert" box of the "Model View" panel.
7. Left click the "next" arrow in the top right of the "Model View" panel.
8. Ensure that a "1:1" scale is selected in the "Scale" box of the "Model View" panel.
9. Hover the mouse over the sheet in the center of the window and left click to place the drawing onto the sheet. Hit "escape" on the keyboard to exit "Model View". If the drawing is not the desired view, complete the following steps:
   (a) Hover the mouse over the drawing to make the dashed perimeter visible.
   (b) Left click on the perimeter.

(c) Select the desired orientation from "Orientation" box of the "Drawing View9" panel.

(d) Left click on the sheet to accept the changes.

10. Save the drawing in the .dxf format by selecting "File" then "Save As", choosing "Dxf" from the drop down "Save as type:" menu and clicking "Save".

11. Close the SolidWorks. Click "No" when prompted to save changes to the drawing unless you also want to save a .dwg file type of the drawing.

## 10.2 Importing the File into SmartCAM Advanced Fabrication v19

Once the SolidWorks file is in the .dxf format it can be imported into SmartCAM Advanced Fabrication v19.

1. Open the Advanced Fabrication v15 application. If you cannot locate the shortcut using the "Start" button try the following path "C:
   Program Files (x86)
   SmartCAM
   SmartCAMv15
   SYSTEM
   afab.exe"

2. Go to the "File" menu and select "Import".

3. In the "Import" dialog box specify the file location in the "From File" text box. You can also browse to find a file location by left clicking "File Select..." Be sure to specify the file type as "DXF" in the "File Type" field.

4. Left click "Accept" to import the dxf.

5. Go to "View" menu and select "Full" to find your imported drawing.

## 10.3 Saving a .pm5 File in SmartCAMv19

The .pm5 file you are creating is a type unique to SmartCAMv15. It is the repository for the information needed to write the final G-code text file. Save the file as a .pm5 by selecting the "File" menu and "Save As". Specify the desired file name and location.

## 10.4 Creating a Tool Path

Before a tool path can be created a job file (.jof) must be loaded.

1. From the top of the Advanced Fabrication window, select "File" then "Load Job File". Select "v15.jof" found in the "C:
   SmartCam Files" directory.
2. Ensure that all the features you wish to be cut by the tool are selected. You can do this by clicking on the "+ +" button on the group toolbar.
3. Go to "Edit" menu, "Property Chg" and select "Toolpath". On the far right of the Advanced Fabrication window near the middle, select the "6:Lsr Cut" tool from the "STEPS" list on the far right. The other cutting tools listed are for other pieces of equipment.
4. Left click "Accept" in the "Toolpath Property Change" dialog box.
5. Save your .pm5 file.

## 10.5 Deleting Elements

You might not wish to cut all the elements in your drawing. They should be deleted.

1. Select "Geo Edit" in the right panel and "Delete" from the list of toolbox options that appears below.
2. Left click on or near an element. The element will disappear from view. The "ELEMENTS" list on the far right will be updated to show its removal. There is an "undo" button near the middle of the main toolbar. It is a blue arrow curving to the left. It can only be used to undo a single step.
3. Save your .pm5 file when done editing.

## 10.6 Changing the Cutting Order

To specify the sequence in which the laser cuts the elements of your part, you must change the cutting order. The outside of the part should be cut last to ensure the part does not shift during the cutting process.

To simplify the code generating process the internal flow path line elements can also be chained together. This orients all tool directions for radial moves to create a continuous line. This is done by:

1. Select “Order Path” from the right panel, and “Chain” from the list of toolbox options that appears below.

2. Left click the “ - - ” button on the group bar to deselect all elements. Deselected elements are drawn with solid lines.

3. Left click the pointer icon in upper left of the Group toolbar. Now select all the line and radial elements that need to be chained together. This would be all the lines that make up the flow channel. Check the circle for “chain” in the open dialogue box and click “group chain”

   To change the cut order once this chain has been created:

4. Select “Order Path” from the right panel, and “Seq Move” from the list of toolbox options that appears below.

5. Left click the “ - - ” button on the group bar to deselect all elements. Deselected elements are drawn with solid lines.

6. Left click the pointer icon in upper left of the Group toolbar. Click on individual elements in the order you wish them to be cut. You can also left click and drag to select a group of features. After all elements are selected in the order in which you want them to be cut, select the “By Group Selection Sequence” in the open dialog box at the bottom of the screen. Left click “Go”. The “ELEMENTS” now shows the updated sequence.

7. Save your .pm5 file.

## 10.7 Creating the G-Code

The G-code can now be written. This will result in a text file containing line-by-line instructions describing the toolpath for your part for written specifically for the ROFIN.

1. Select the “Process” menu and “Code”.

2. In the “Code” dialog box, left click “File Select” to open the “Save As” dialog box. Enter the name the G-code file to be written and select the directory it is to be saved in. Left click “Save” to exit the ‘Save As” dialog box.

3. Select “Choose” to open “Job Information” dialog box. With the “Machine File” text box highlighted, select “File Select”. Double click on “Rofin.smf”. With the “Template File” text box highlighted, select “File Select”. Double click on “Rofin.cgt”. The “Machine File” and “Template File” text boxes should now be updated. Click “Accept” to close the “Job Information” dialog box.

4. In the “Code” dialog box, set the “Speed” to 9, “Show Tool” to “Draw End”. Also ensure the “Code =” is checked and the “Show Path” is unchecked. Each of these options serves to minimize the time it takes to write the code.

5. Click “Start” to start writing the G-code. The code is actively displayed to the right of “Code =”. When the coding is done, the displayed code will no longer change and the “Start” button will no longer be grayed out.

6. Save your .pm5 file.

## 10.8 Viewing and Editing the G-Code

The G-code can now be viewed and edited using a text editor such as Notepad. Editing is not required but it does offer the user greater process control.

1. Right click on the Windows “Start” button and left click on “Explore”. Navigate to where you saved your G-code. Your G-code file will not have a specific file extension such as “.txt”, “.pm5”, or “.jof”.

2. Double click on the file name and left click “Open” in the “Open File” dialog box.

3. Double click on “Notepad” in the “Open With” dialog box.

4. Your G-code should now be displayed. Below are the definitions of the characters you see.

   (a) FARCALL $STRGLOB0 "LASERON" : Rofin specific command to fire laser

   (b) FARCALL $STRGLOB0 "LASEROFF" : Rofin specific command to turn off laser

The Rofin does not start from a reference point in the drawing, so aligning the part within the Rofin system and selecting a starting location in the drawing is important.

### 10.9 Transferring the G-Code to the Rofin

The Rofin is connected to the OSU wireless internet connection so there are a variety of ways to transfer files to the system. If you have a folder on the MBI Root drive, you can access this folder on the Rofin. Otherwise, e-mail or USB thumb drives work as well. To use a thumb drive, install it in one of the front USB ports on the computer. The computer is located inside the lower-right cabinet on the Rofin workstation. The right USB port is for users.

**DO NOT REMOVE THE DONGLE IN THE LEFT USB PORT AS THIS DONGLE IS REQUIRED FOR PROPER TOOL OPERATION!!**

## 11 Program Templates

This section provides detail corresponding to the various sections and callouts within the cutting and fixed mode welding templates.

### 11.1 Cutting Template

This section covers detail on the cutting program template.

### 11.2 Fixed Mode Welding Template

This section covers detail on the fixed mode welding program template.