Fanuc Ten Point Camera Calibration

Scope of Document

Scope of Document

- The scope of this document is to ensure the proper setup and procedure for calibrating a Servo-Robot camera with a Fanuc robot.
- This document will show a step-by-step approach using Fanuc's Ten Point calibration method, for proper setup no information should be skipped or overlooked.
- The information pertained in this document is derived from the Fanuc Setup and Operations manual.

Systems Used

Systems Used in Procedure

Servo Robot Power-Trac system

Fanuc R-30iB controller with an ARC Mate 100iC arm

Requirements

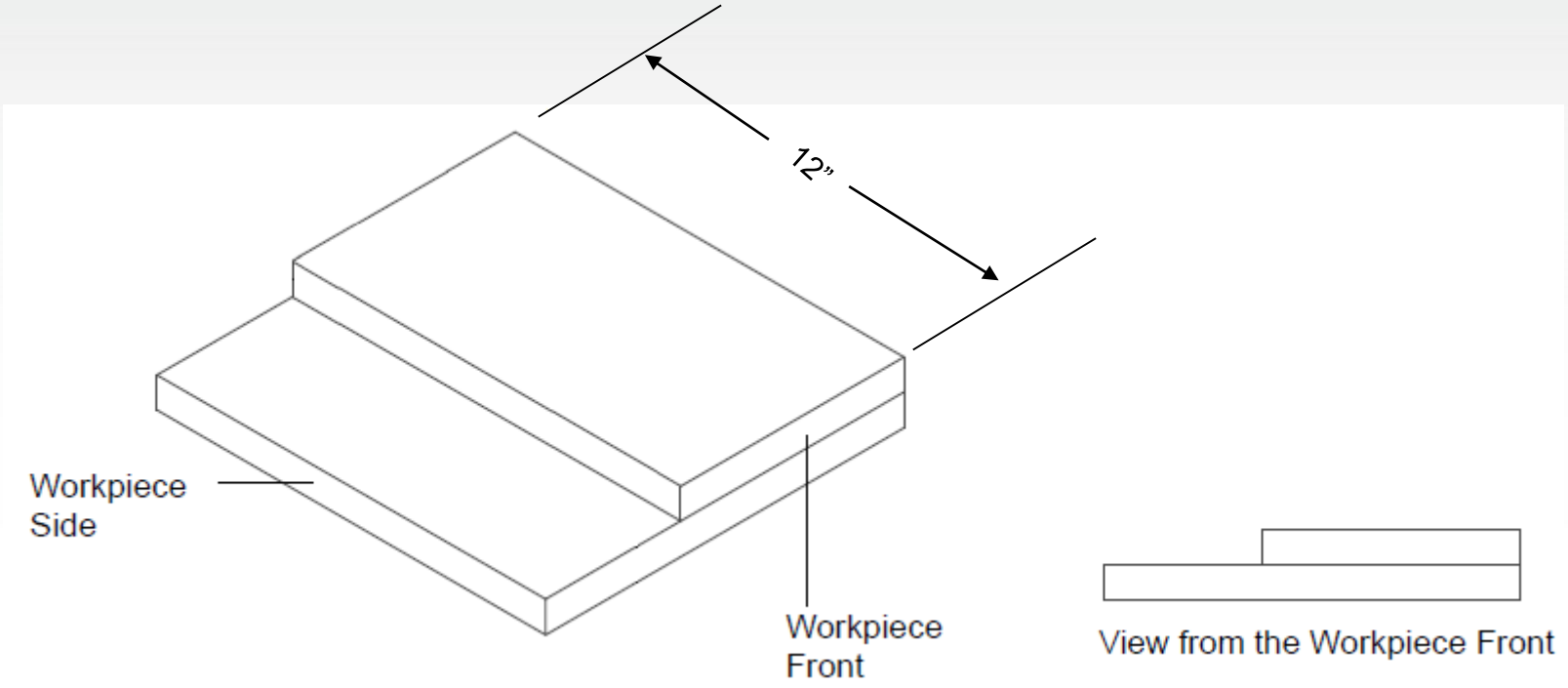
Requirements

- This document is under the assumption that the Servo Robot system has been properly installed, configured, and communication verified by the Fanuc robot prior to the Ten Point calibration.
- Additionally, a Tool Frame with an accurate TCP needs to be setup prior to setting up the Ten Point calibration.

Lap Joint

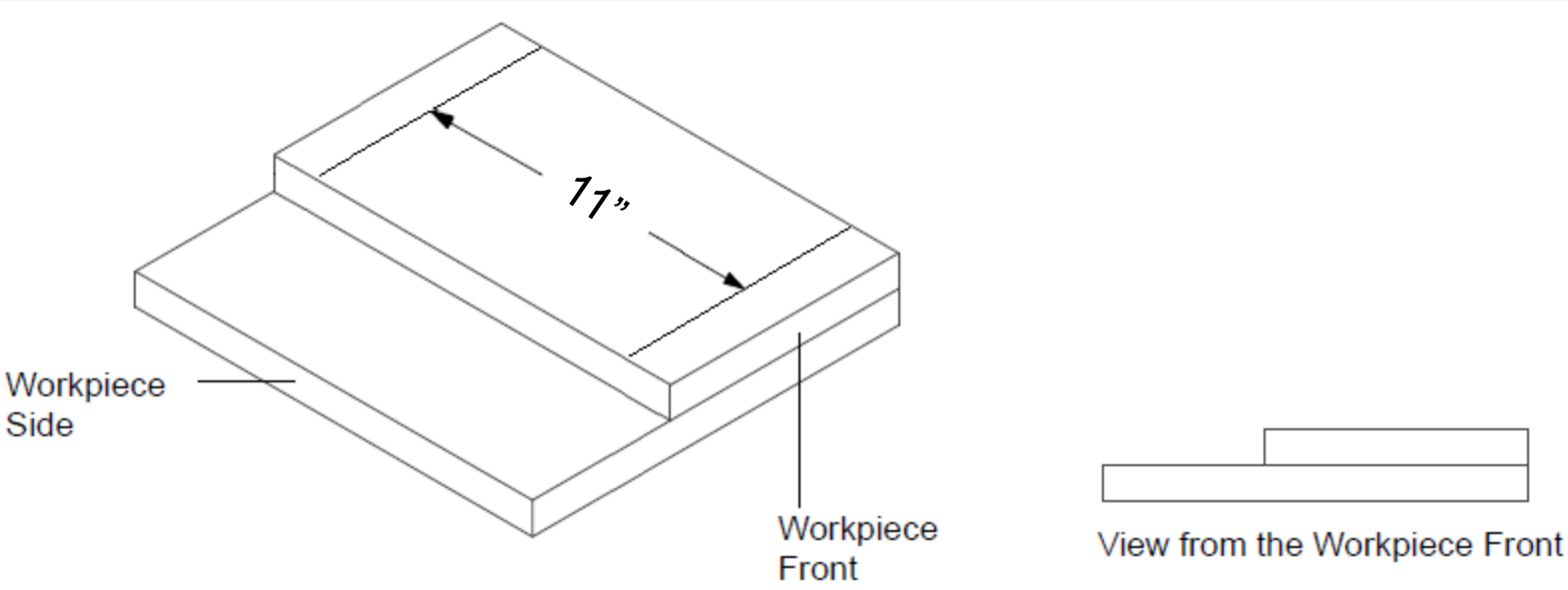
Create a Lap Joint

- A lap joint will need to be created with the top plate having a sharp square edge. There should be no gap between the base plate and top plate. Overall length should be 12 inches.



Mark Out Lap Joint

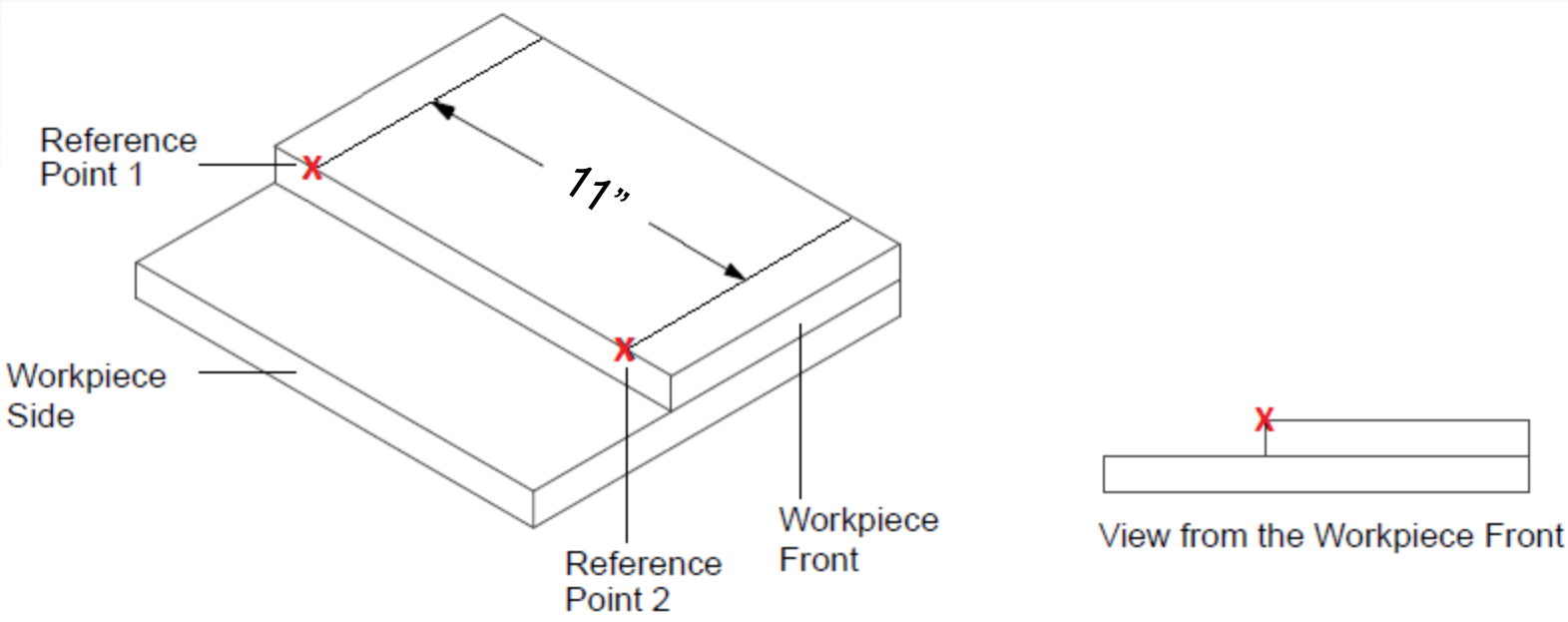
- Measure 1/2 inch inward from both ends of the plate and using a thin marker or metal scribe, mark out a straight line perpendicular to the joint.
- The distance between the marked lines should be 11 inches.



Reference Points

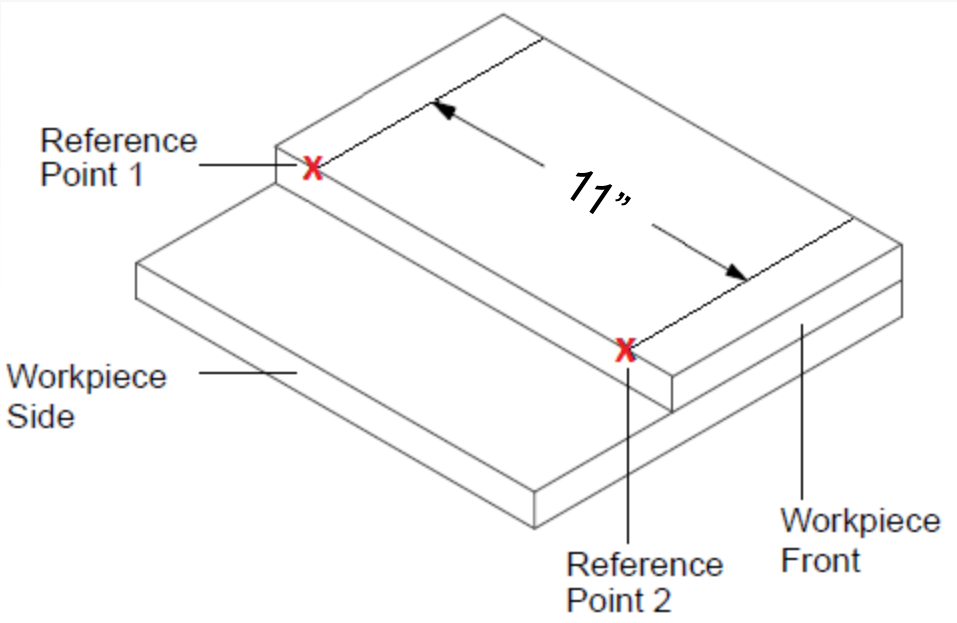
Reference Points 1 & 2

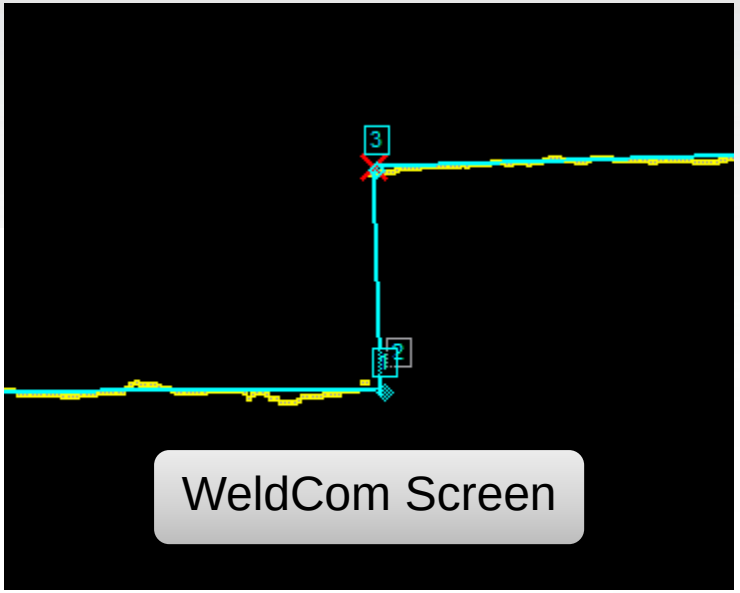
- These lines will help the operator navigate the TCP and laser line of the camera to the reference points. The reference points are on the top edge of the top plate, and they will be referred to as Reference Point 1 and Reference Point 2. The reference points also represent the placement of the tracking point on the joint profile in WeldCom.

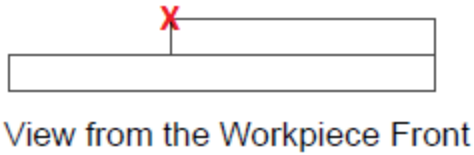


Reference Points - Continued

- This shows the relation of the reference points on the calibration plate to the tracking point (red X) on the joint profile in WeldCom when a task is created.



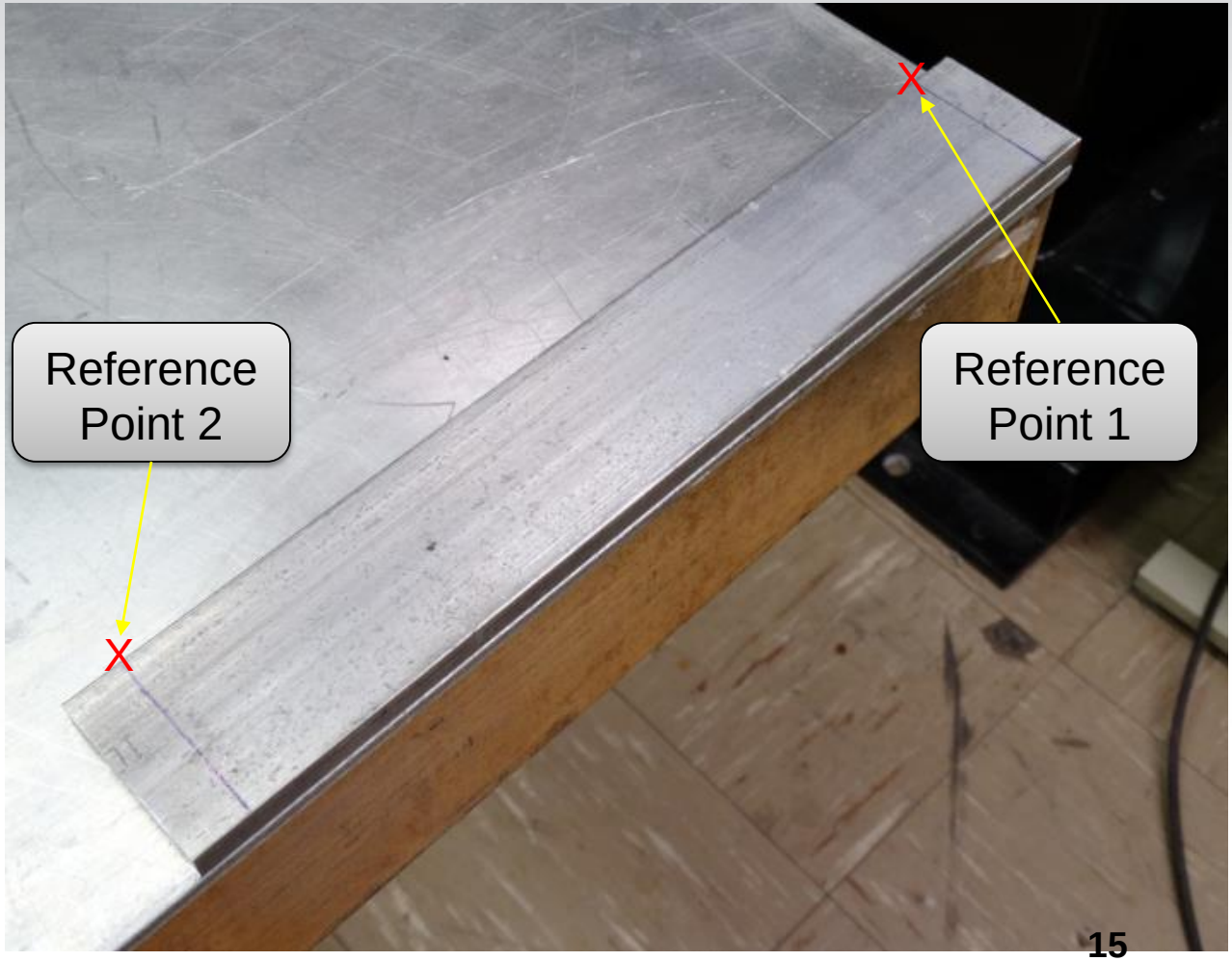




Create a Joint Profile

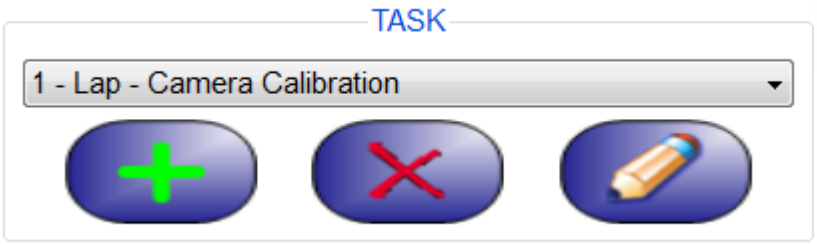
Positioning Calibration Plate

- Position the calibration plate so Reference Point 1 is facing the edge of the table as shown in the photo.
- This will help add some clearance for the torch when the calibration routine is executed.



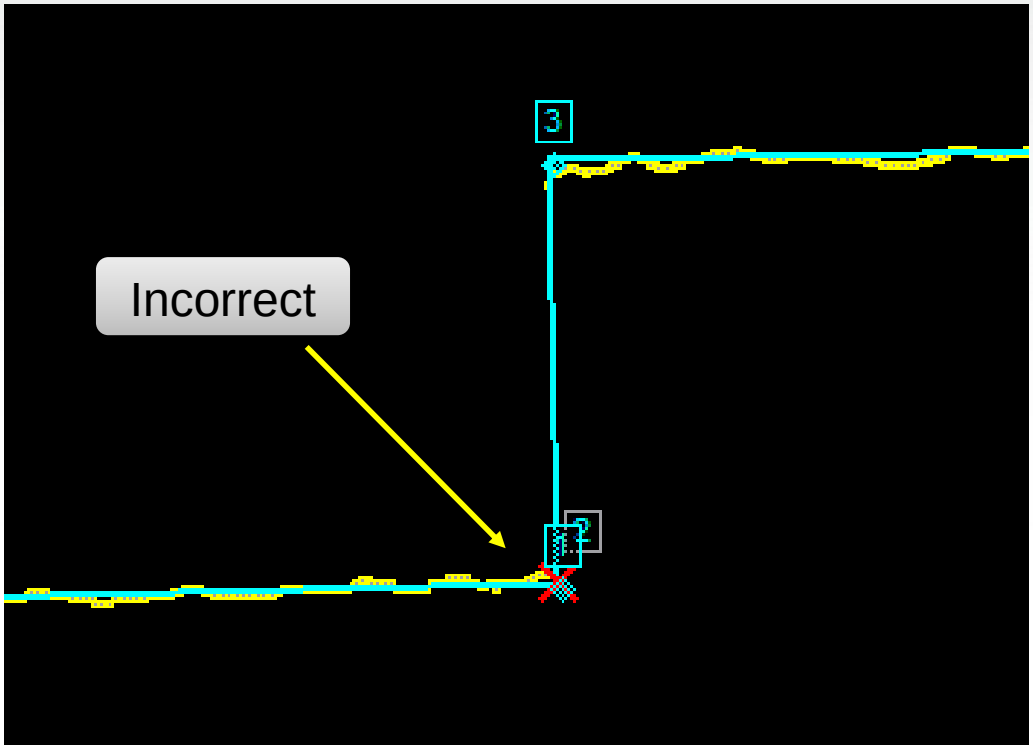
Position Camera Over Joint

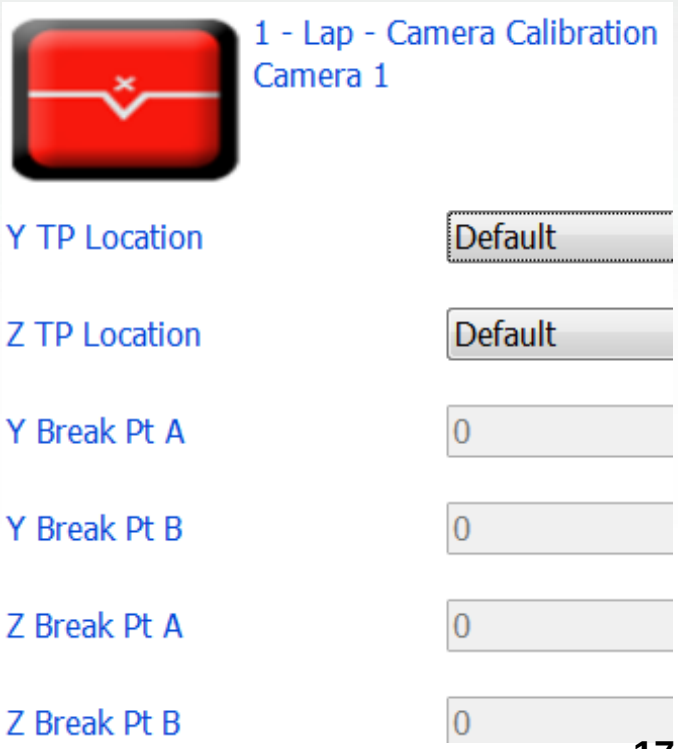
- Connect to WeldCom and turn on the laser.
- Position the robot so the laser stripe lines up with Reference Point 1.
- When the joint is in the field of view of the camera create a new task.
- In WeldCom the task number MUST be #1.



Setup Task 1

- Once you are able to recognize the joint check the tracking point (red X). Default settings will typically place the tracking point in the root. This is incorrect for the calibration sequence and must be changed.





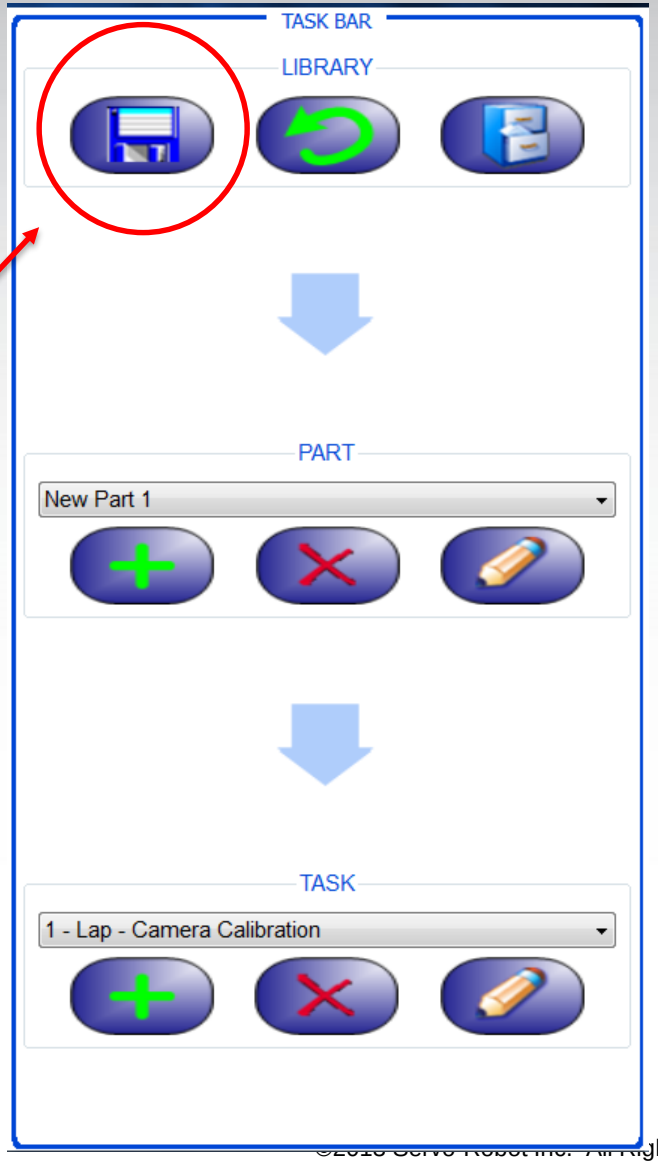
Setup Task 1 - Continued

- Adjust the settings so that the tracking point (red X) is at the top edge of the top plate.

Setup Task 1 - Continued

- Once you are satisfied with the joint profile save your settings at the main page.

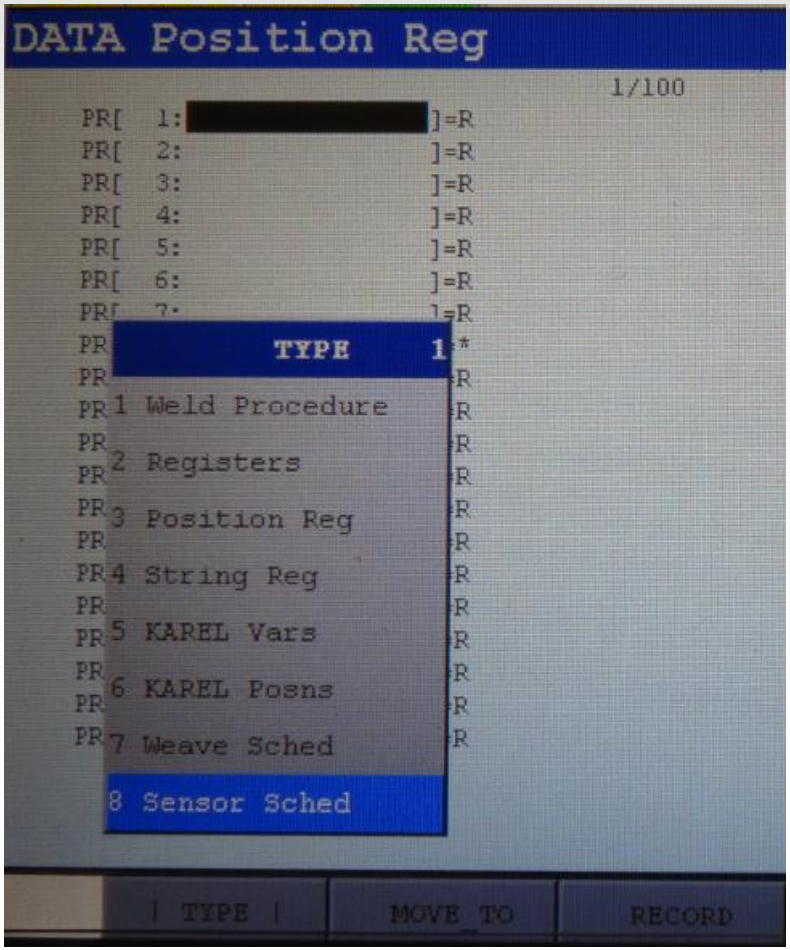
SAVE!

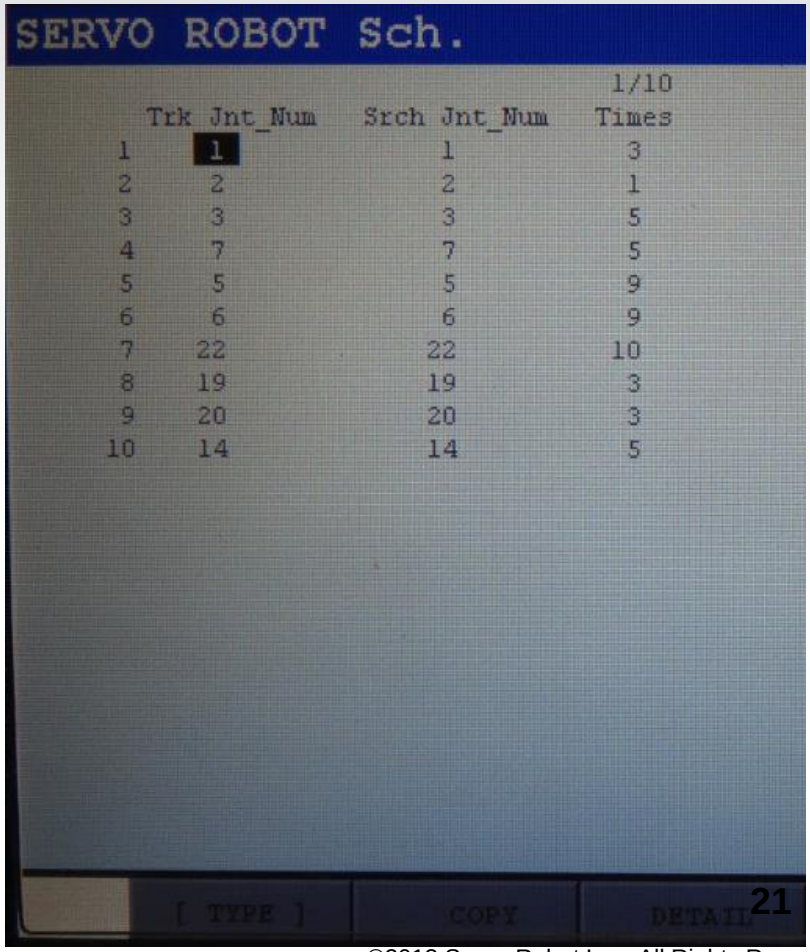


Setup Sensor Schedule

Getting to the Sensor Schedule

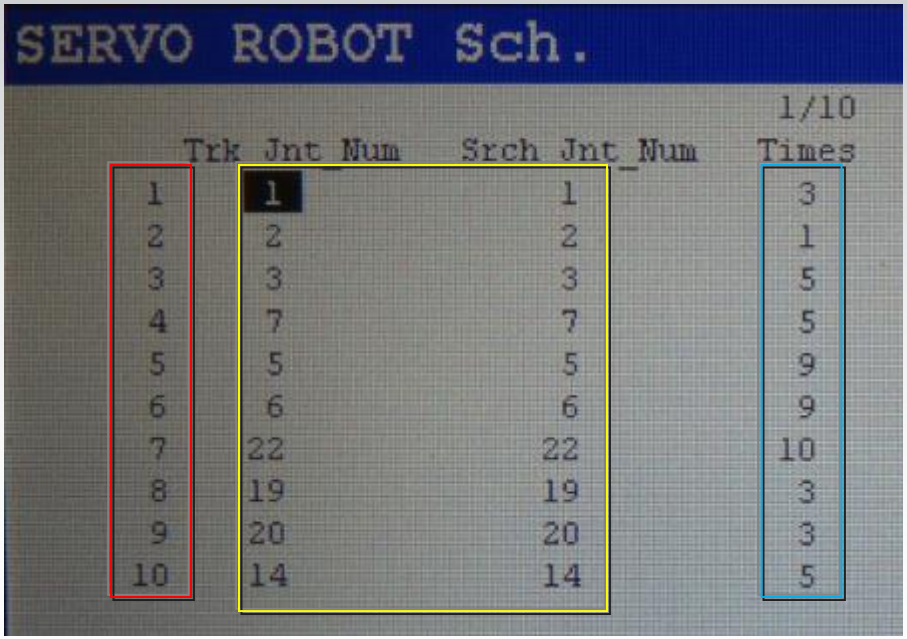
- Press DATA → Type(F1) → Sensor Sched → Enter





Sensor Schedule Main Page

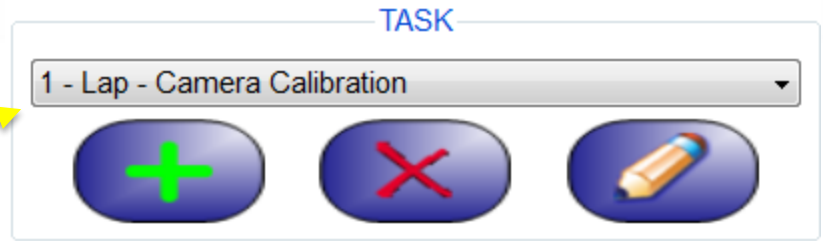
1st column represents the sensor schedule numbers, these are the numbers used during programming.
They are similar to the way a weld schedule is used in the arc start.



The 4th column is a detection count, this is the number of times the joint is detected per search execution. Use 3-5 as a default.

The numbers in the 2nd and 3rd columns are task numbers from the WeldCom library. Within each schedule you define what task number is used for the Tracking and Searching sequences.

i.e. Schedule 1 says we will Track and Search with Task #1 from WeldCom.



Setting up a Sensor Schedule

- Select Sensor Schedule #1, you MUST use schedule #1 for the calibration procedure.
- Press Detail(F3) and the screen on the right will pop up.
- There is Tracking Setup and Search Setup.
- **Note: For the Ten Point method we will only be using the Search function**.

```
SERVO ROBOT Sch.
                                        1/26
  1 Servo Robot Schedule:1\ [********]

Tracking Setup
  2 SR Track Joint Num          1
  3 Tracking Type               Standard
  4 Motion Sensitivity          3
  5 Y-Bias   (mm)               0.00
  6 Z-Bias   (mm)               0.00
  7 Stationary Track Frame      0
  8 Tack Avoidance              Disable
  9 Tack Threshold(mm)          2.00
 10 Tack Length (mm)            40.00
 11 Joint End Detect            Enable
 12 Start Distance(mm)          250
 13 Detect DO Index             1
 14 Joint End OFS (mm)          0
Search Setup
 15 SR Search Joint Num         1
 16 Search Type                 Position
 17 Detection Count             3
 18 Retry Count                 0
 19 Retry Direction             X
 20 Retry Distance (mm)         3.0
 21 Y-Bias   (mm)               0.00
 22 Z-Bias   (mm)               0.00
 23 Search Frame                UFRAME
 24 Dynamic Search              Enable
 25 Search Dist (mm)            100.00
 26 Search Spd (mm/sec)         250.00
```

Sensor Schedule 1 Values

- Adjust the setting so it matches the screen below.

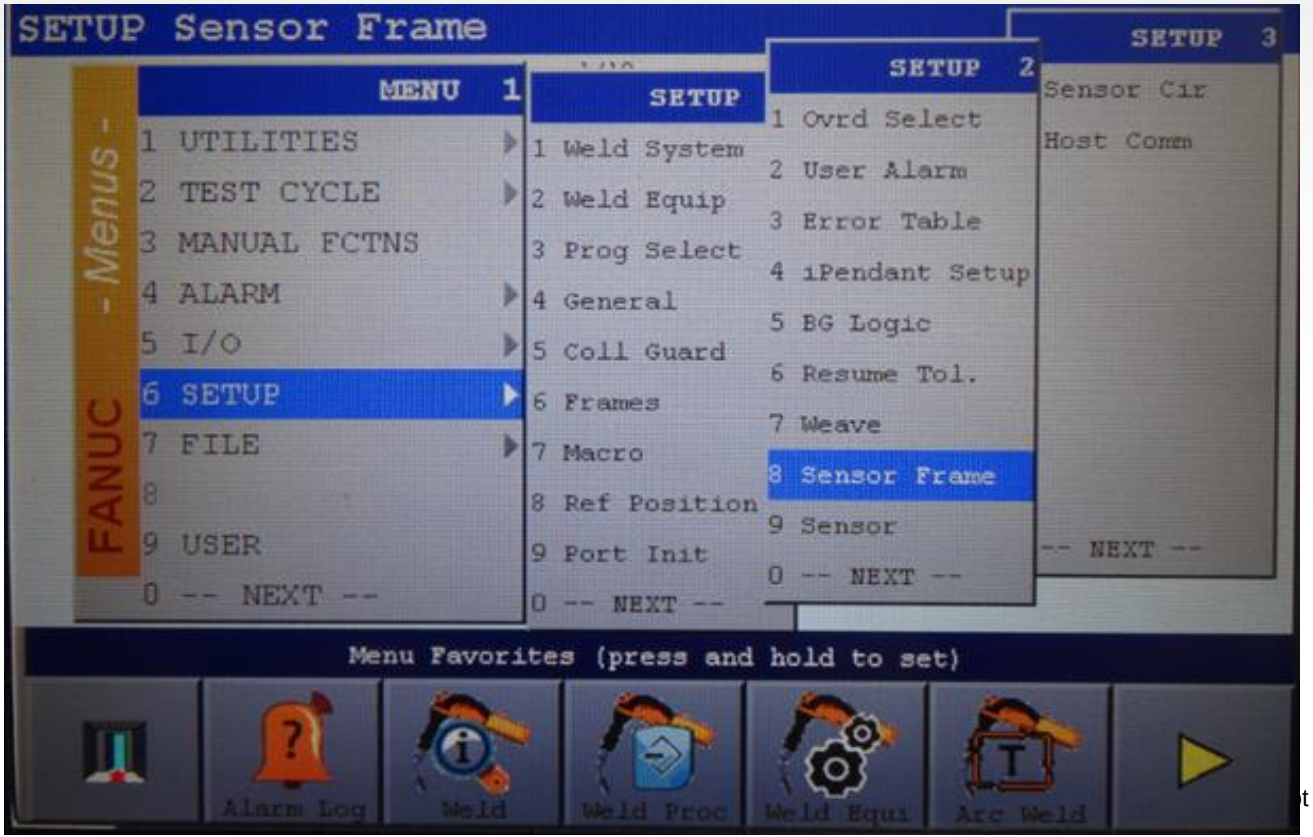
```
Search Setup
 15 SR Search Joint Num       1
 16 Search Type               Position
 17 Detection Count           3
 18 Retry Count               0
 19 Retry Direction           X
 20 Retry Distance (mm)       3.0
 21 Y-Bias  (mm)              0.00
 22 Z-Bias  (mm)              0.00
 23 Search Frame              UFRAME
 24 Dynamic Search            Disable
 25 Search Dist (mm)          100.00
 26 Search Spd (mm/sec)       250.00
```

Setup Sensor Frame

Getting to Sensor Frame

- After sensor schedule 1 is set we need to setup the Sensor Frame.
- Press:

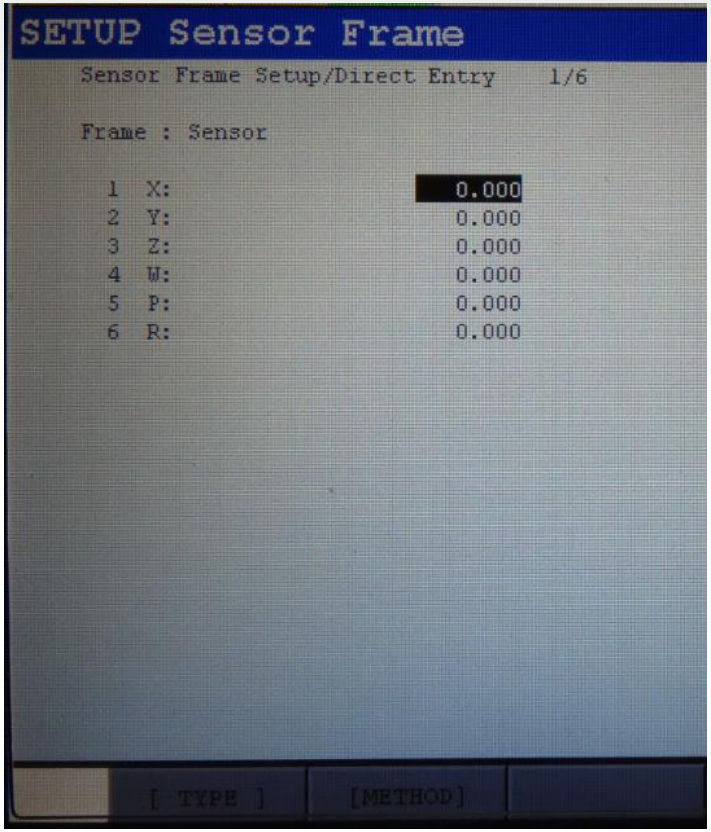
  MENU → SETUP → Sensor Frame → ENTER

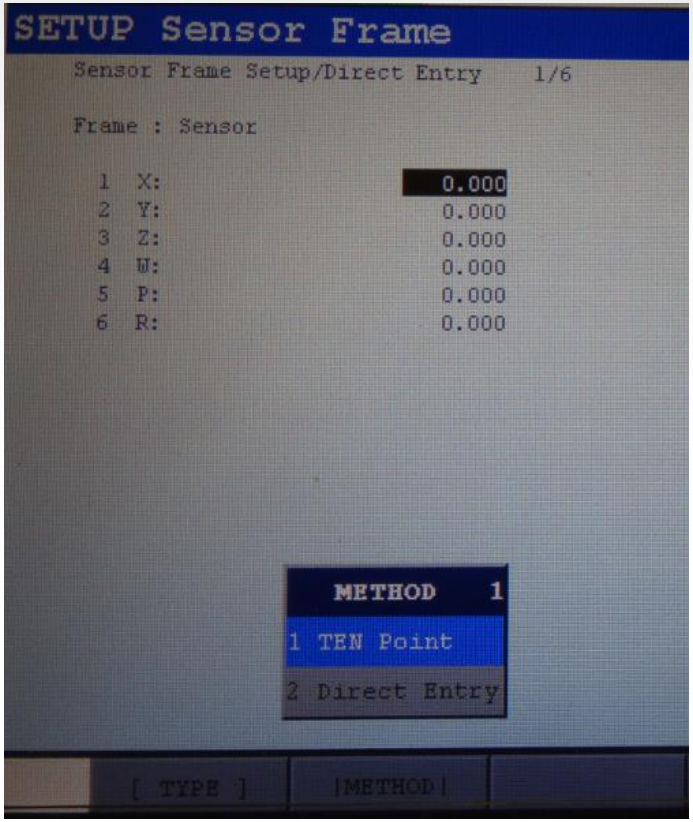


Choosing Ten Point Method

- Direct Entry is the default screen for setting up the sensor frame.
- Press:

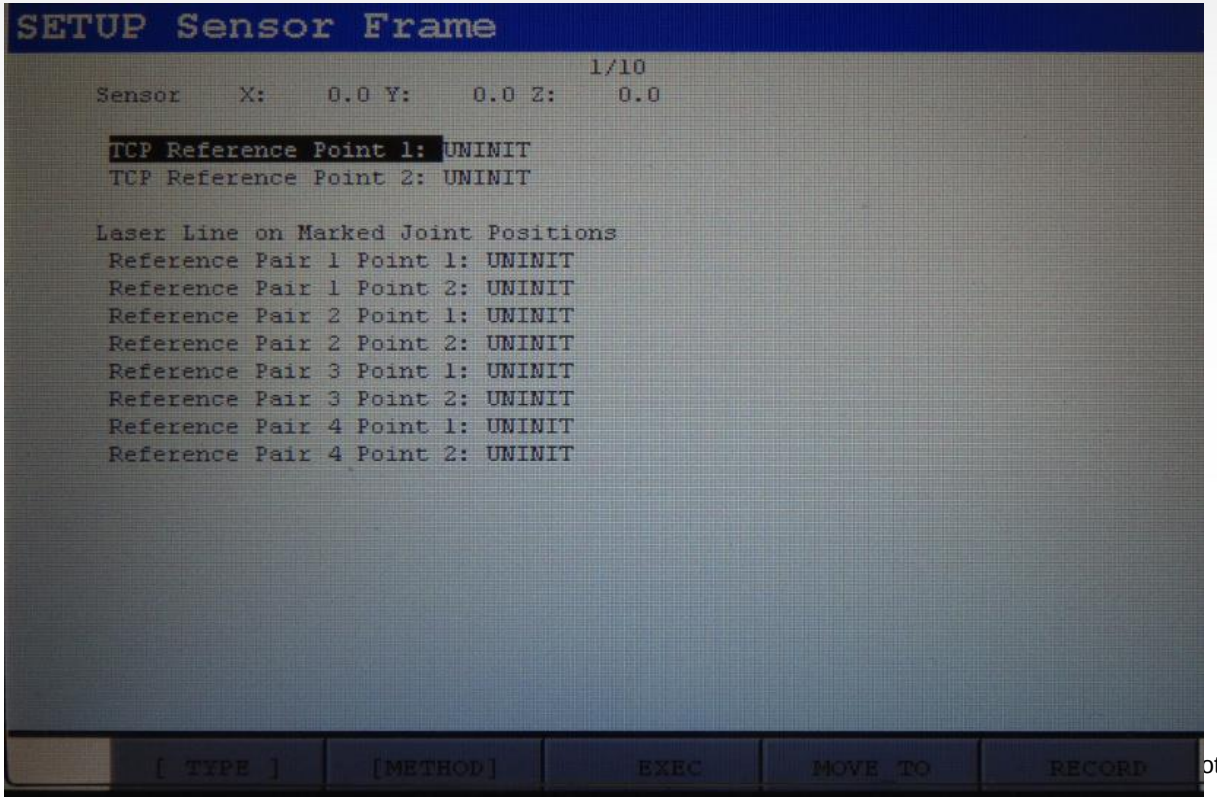
  Method(F2) → TEN Point → ENTER





Ten Point Default Screen

- The positions for the Ten Point method will say “UNINIT”, since no frame has been calculated yet.
- If the positions say ‘RECORDED” you can delete the current sensor frame and start over by pressing NEXT → Delete(F4) → Yes(F4).



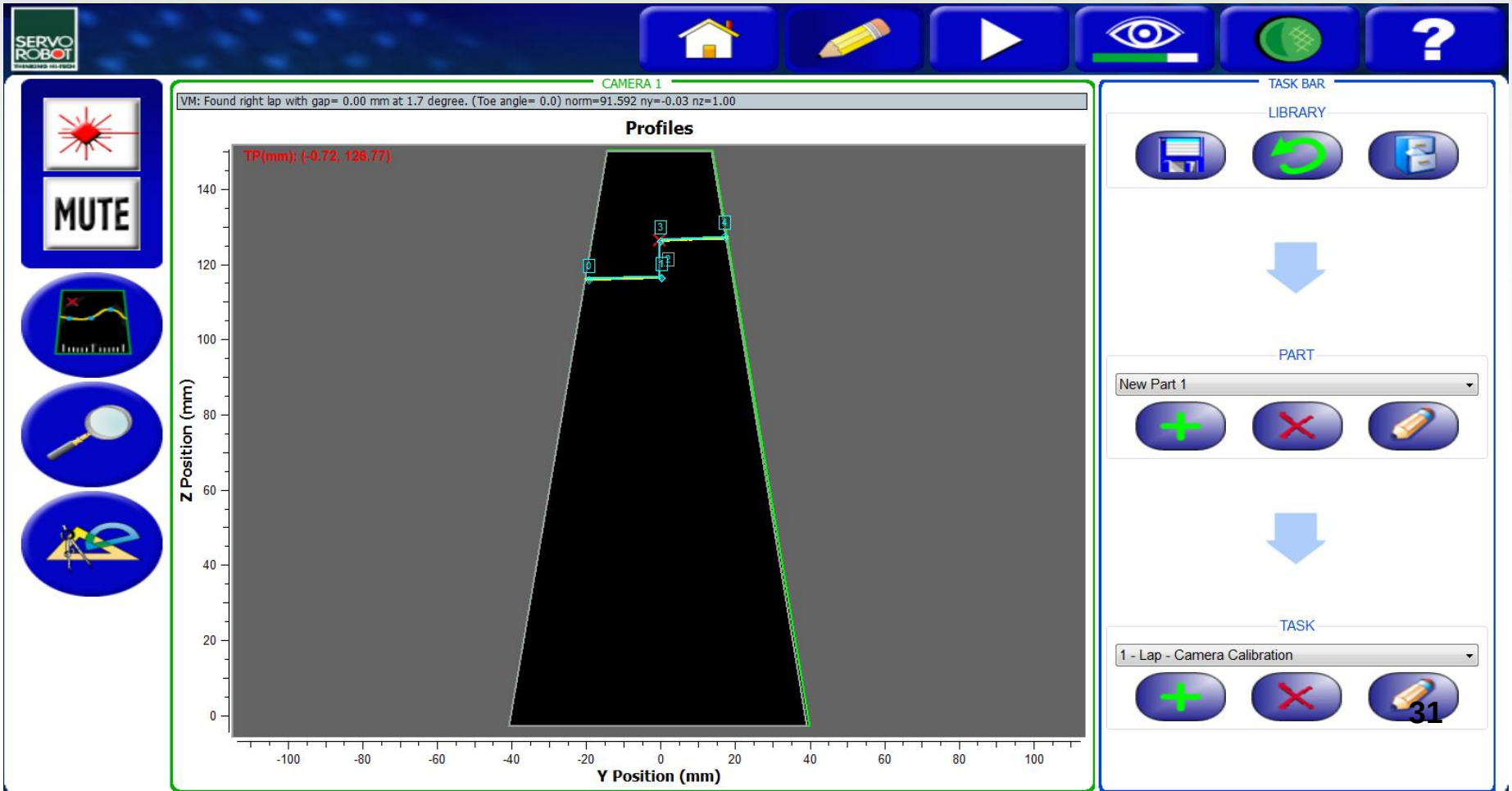
Key Items Prior to Programming

Key Items of Importance

- There are 5 pairs of Reference Points that need to be recorded, hence the name “Ten Point” Calibration.
- First the TCP will need to be recorded at Reference Point 1, and then moved to Reference Point 2, and recorded. Then we need to do the same with the laser line of the camera at the Reference Points.
- Every pair(Pair 0, 1, 2, 3, and 4) has its own specific angle and offset the points need to be recorded at.
- 2 different coordinate systems will be used for the Ten Point calibration method: WORLD & TOOL.
  - WORLD is used for moving from point 1 to point 2 in a linear fashion.
  - TOOL is used for changing the torch orientation for the different pairs.
- For every pair, when a position is recorded at Reference Point 1, the operator MUST maintain the same torch orientation when moving to Reference Point 2. That means in WORLD cord. using only X(J1), Y(J2), and Z(J3) when moving to Reference Point 2. If the angle is change during this transition there is potential for a miscalculation of the sensor frame.

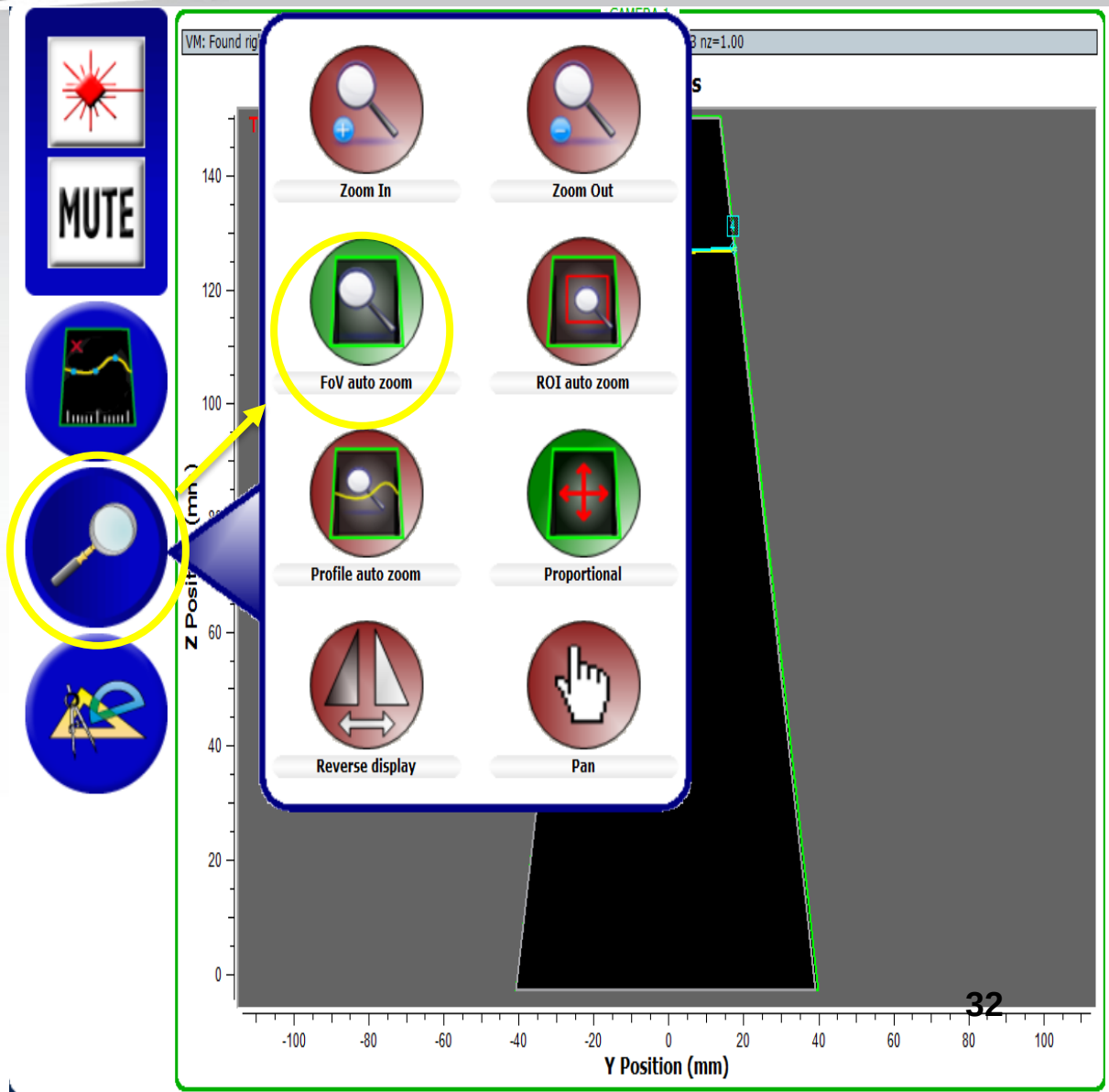
Key Items of Importance - Continued

- A laptop displaying the joint in WeldCom is necessary. The full Field Of View on the screen is required.



Key Items of Importance - Continued

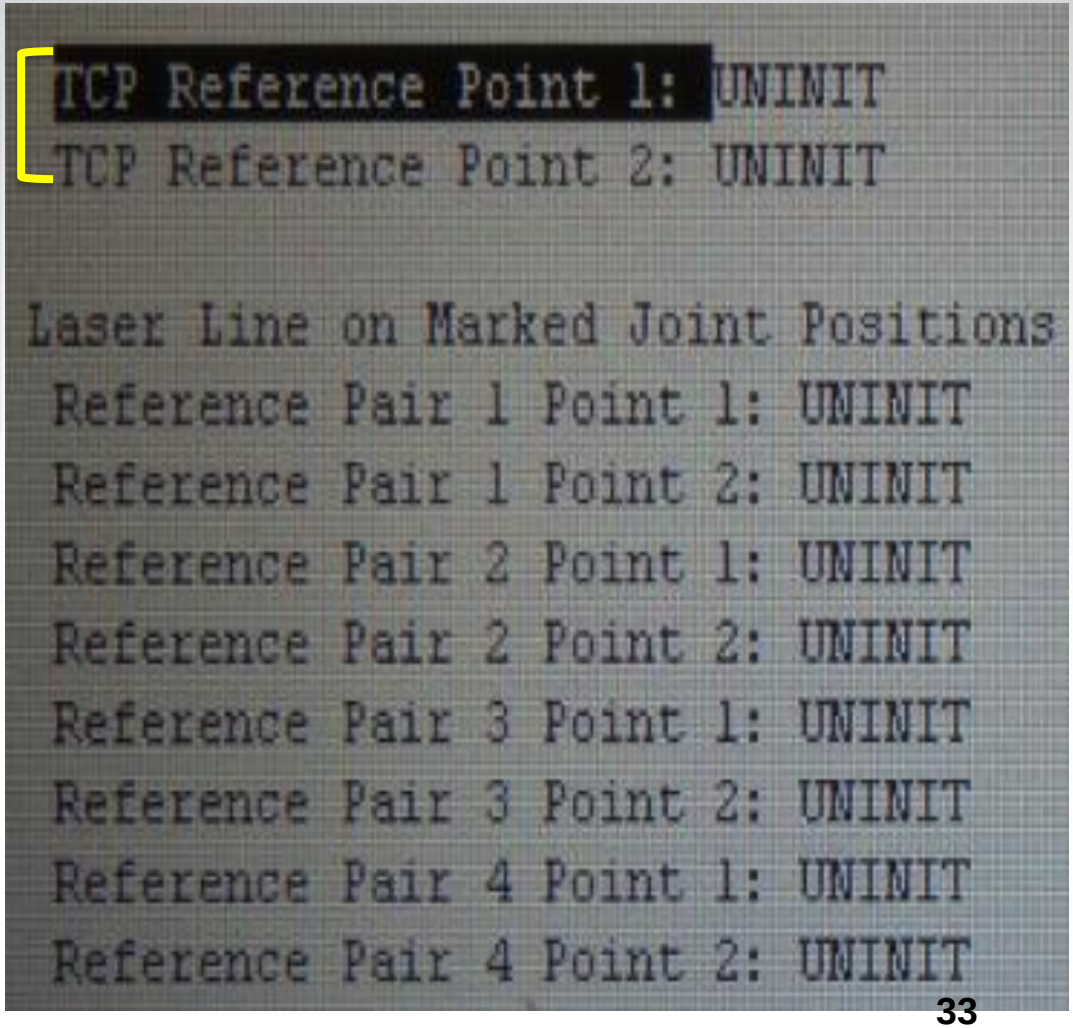
- To get the full Field Of View press the Zoom button (magnifying glass) and select “FoV auto zoom”.
- Viewing WeldCom will be used when we place the LASER LINE on the reference points.



Ten Point Preview – Sensor Frame

TCP (Tool Center Point)
Reference Point 1 & 2

- As close to 0º torch rotation(w,J4 & p,J5) the TCP will be placed on Reference Point 1, recorded, then moved to Reference Point 2 and recorded.

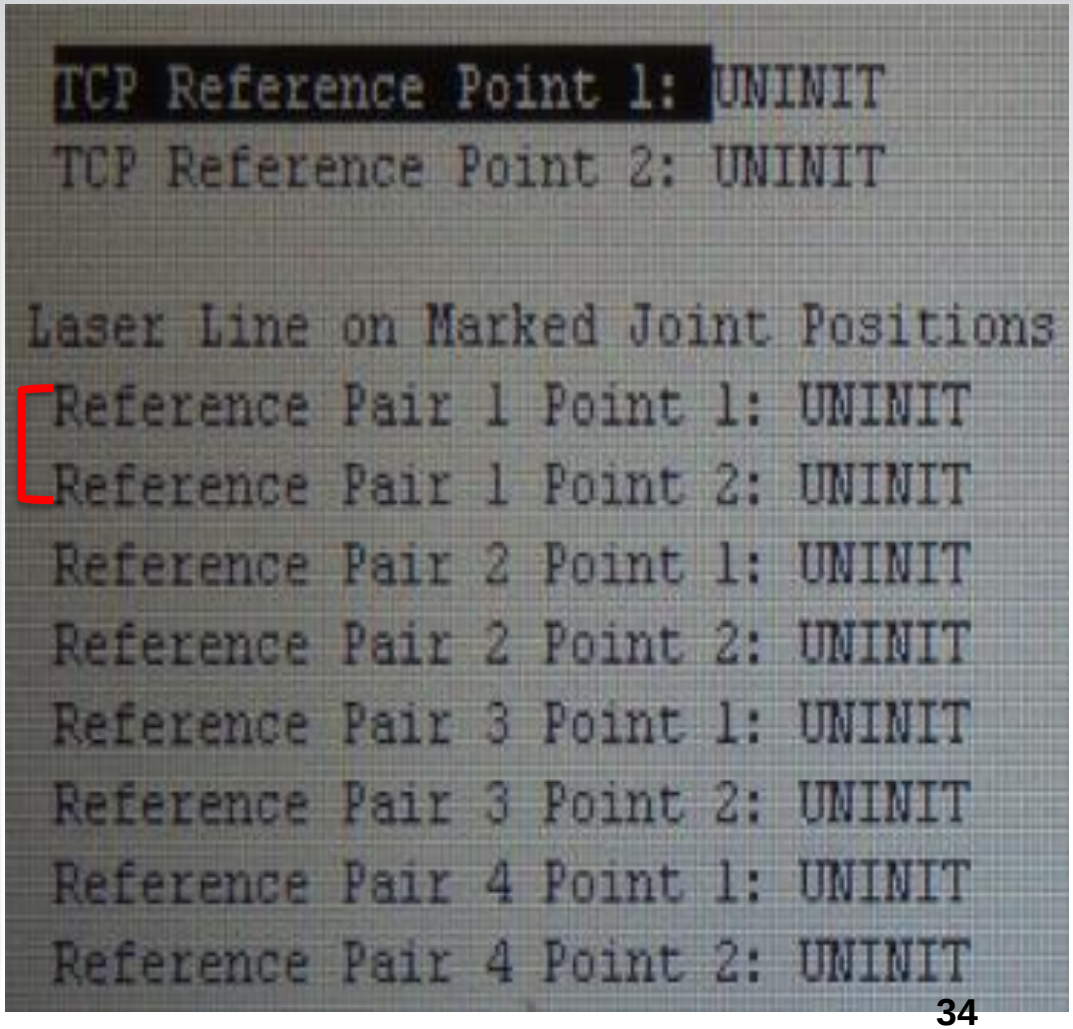


Ten Point Preview – Sensor Frame Continued

Laser Line

Reference Pair 1, Point 1 & 2

- Pair 1 will have the same torch orientation that was used for the TCP Reference Points, even if your camera has a 15-20^{o} drag towards the torch.
- Pair 1 Point 1 will also be our “origin” when we reposition the torch angle for pairs 2, 3, and 4.
- As close to 0^{o} torch rotation(w,J4 & p,J5) the laser line will be placed on Reference Point 1, recorded, then moved to Reference Point 2 and recorded.

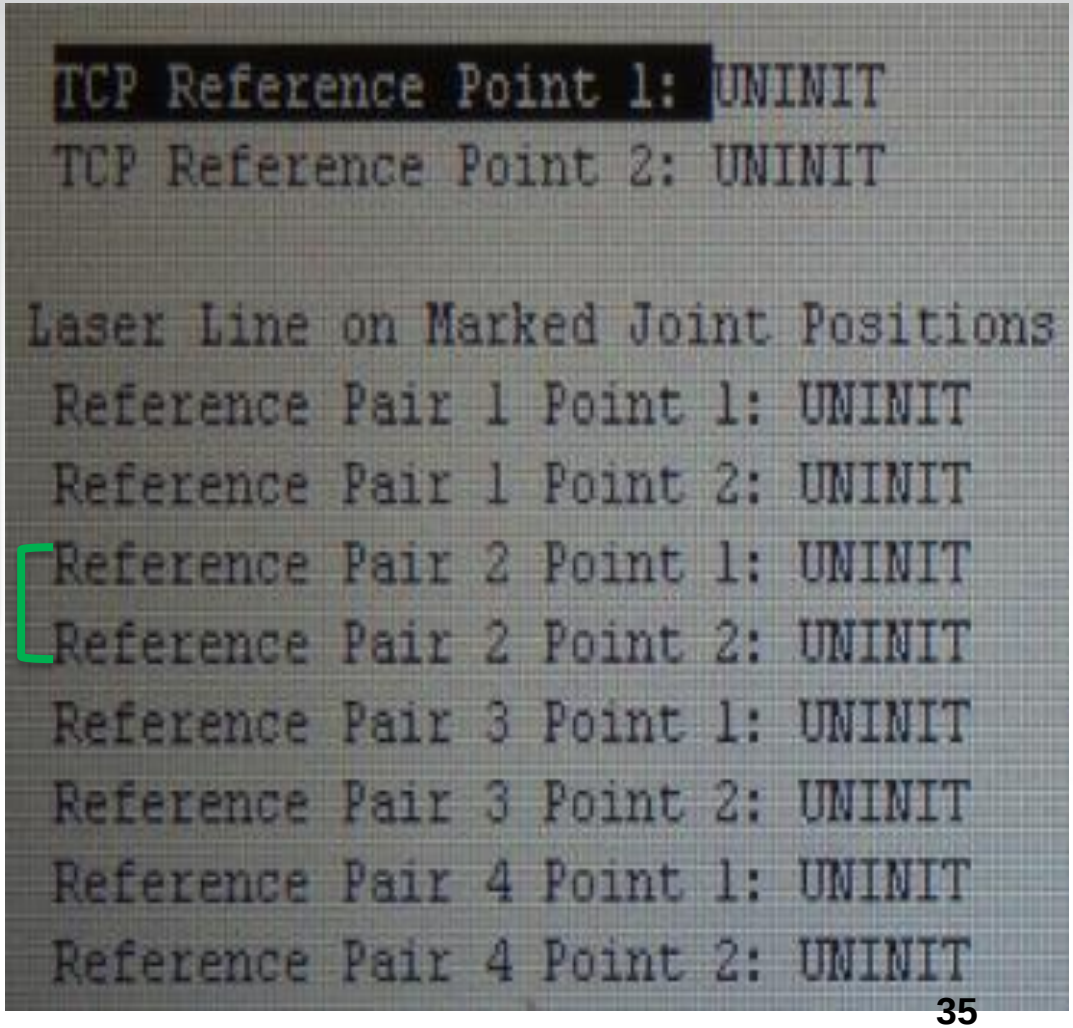


Ten Point Preview – Sensor Frame Continued

Laser Line

Reference Pair 2, Point 1 & 2

- With a positive 5-10º torch rotation in w(+X,J4), p(+Y,J5), and r(+Z,J6) the laser line will be placed on Reference Point 1, recorded, then moved to Reference Point 2 and recorded.

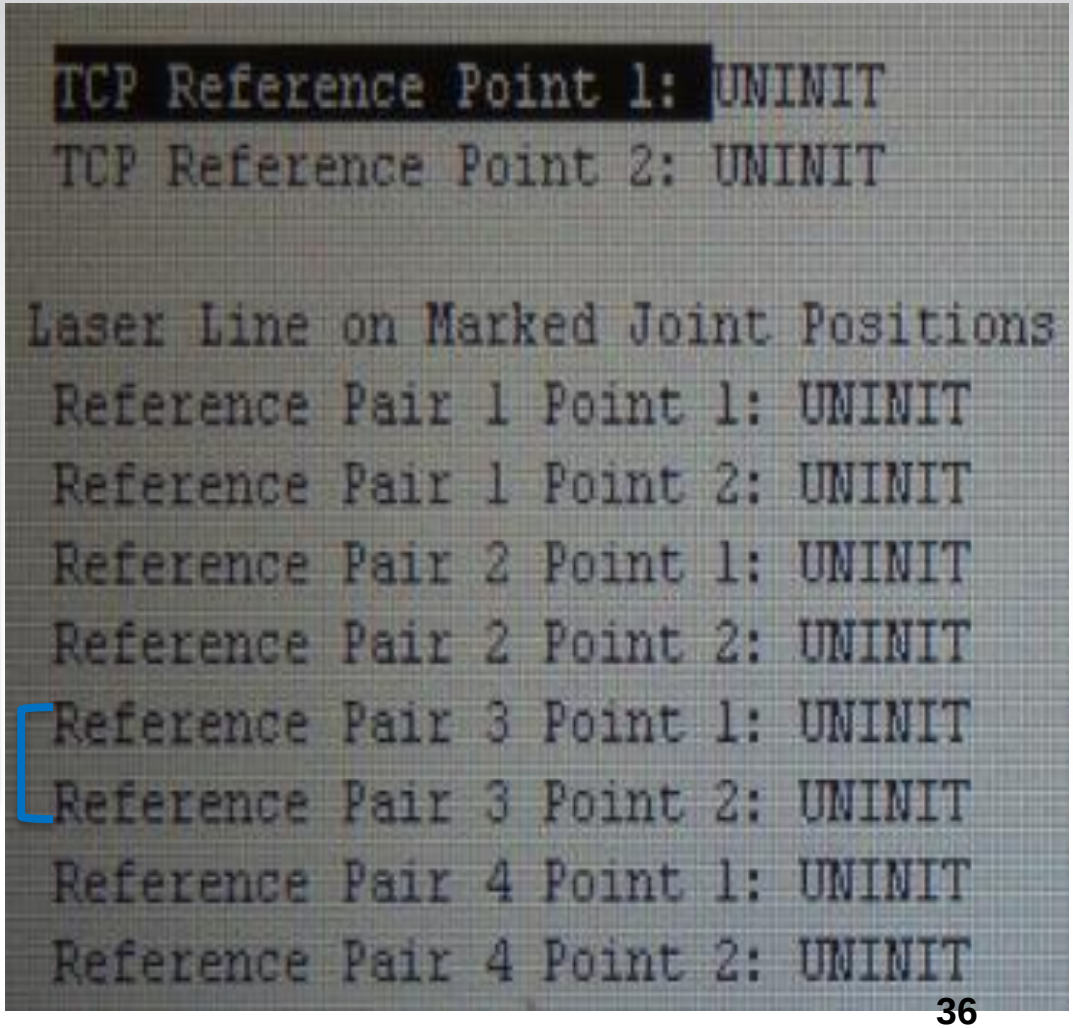


Ten Point Preview – Sensor Frame Continued

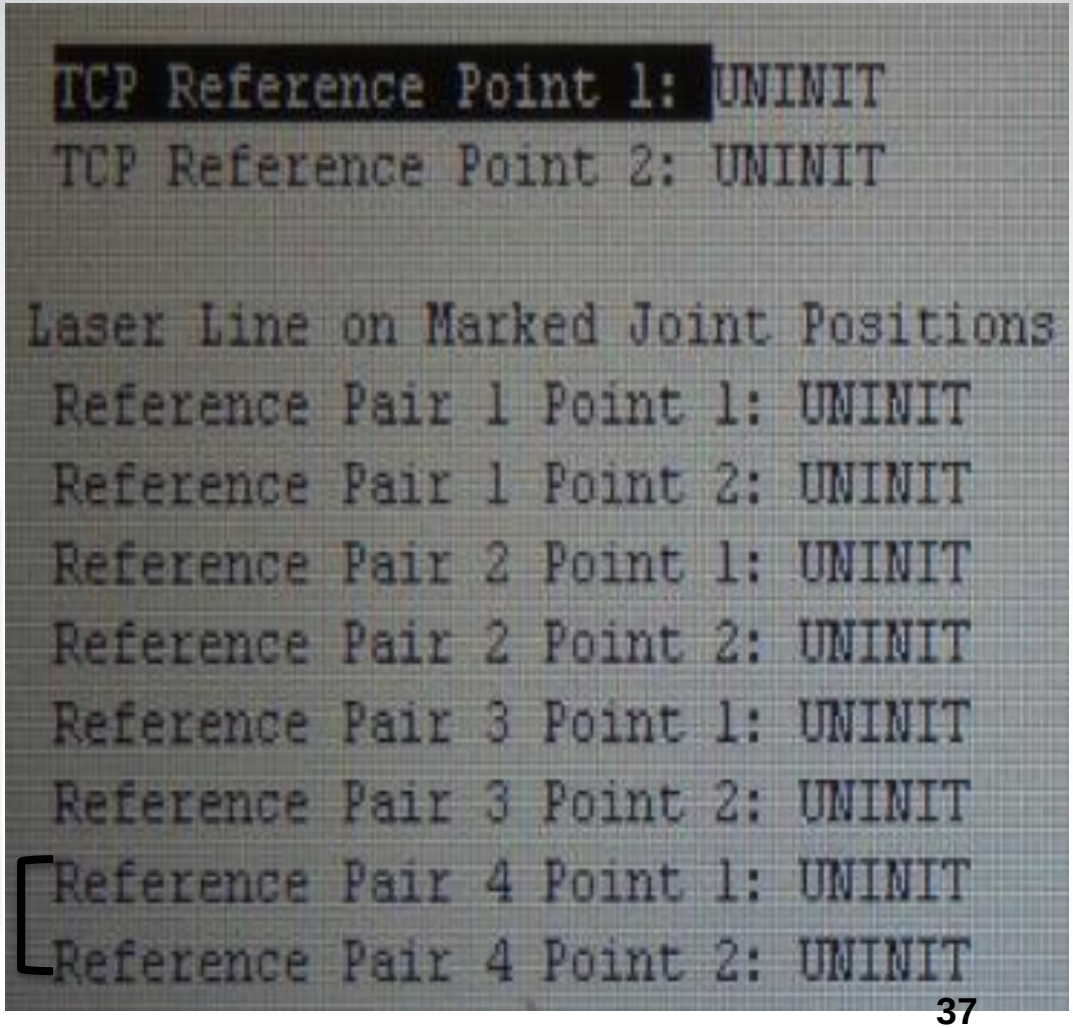
Laser Line

Reference Pair 3, Point 1 & 2

- With a positive 5-10º torch rotation in p(+Y,J5), and r(+Z,J6) the laser line will be placed on Reference Point 1, recorded, then moved to Reference Point 2 and recorded.



Ten Point Preview – Sensor Frame Continued



Laser Line

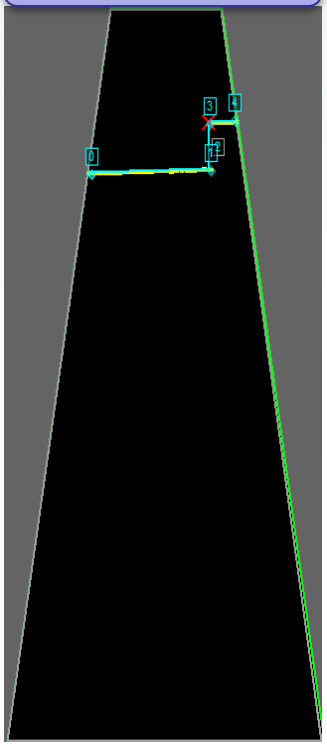
Reference Pair 4, Point 1 & 2

- With a negative 5-10^{o} torch rotation in p(+Y,J5), and r(+Z,J6) the laser line will be placed on Reference Point 1, recorded, then moved to Reference Point 2 and recorded.

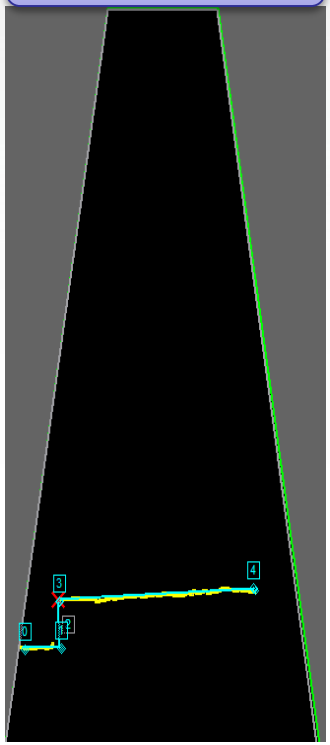
Ten Point Preview – WeldCom View

- Along with the torch orientation, we also need to create a crisscrossing effect for each point. When viewing through WeldCom we will start in the top right corner of the screen for Pair 1 Point 1, record point, and then move “down” to the bottom left of the screen for Pair 1 Point 2, record. For Pair 2 Point 2 we will start in the top left this time then go to bottom right for Pair 2 Point 2.

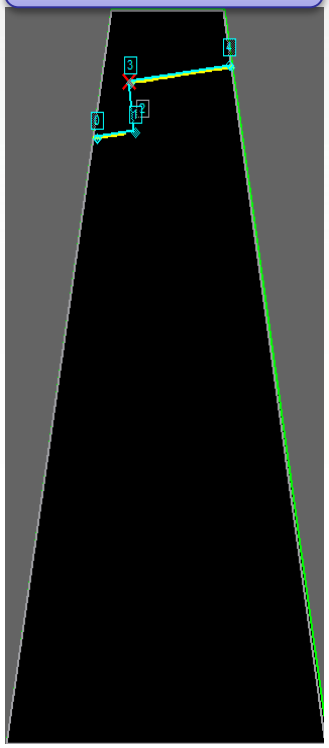
Pair 1 Point 1



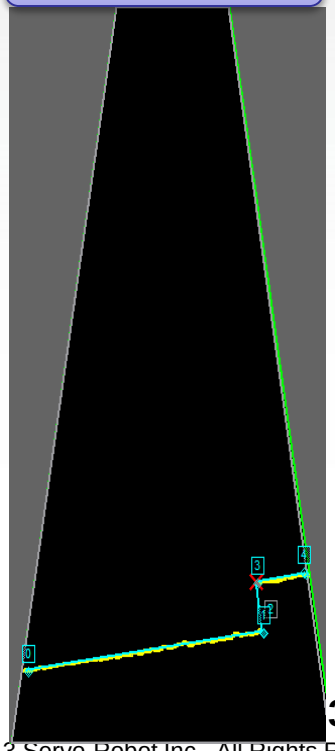
Pair 1 Point 2



Pair 2 Point 1



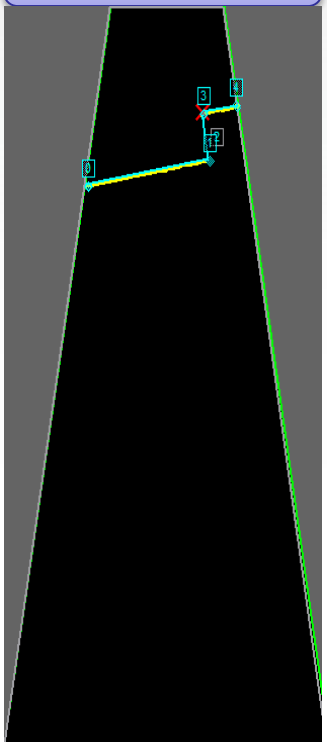
Pair 2 Point 2



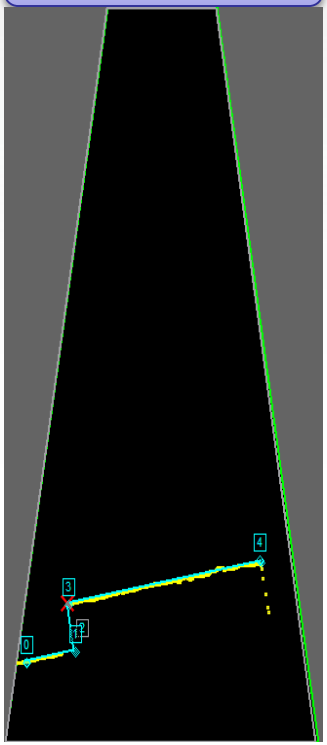
Ten Point Preview – WeldCom View Cont.

- Then we'll start back in the top right corner for Pair 3 Point 1, and repeat the same crisscross pattern once more for Pairs 3 and 4.

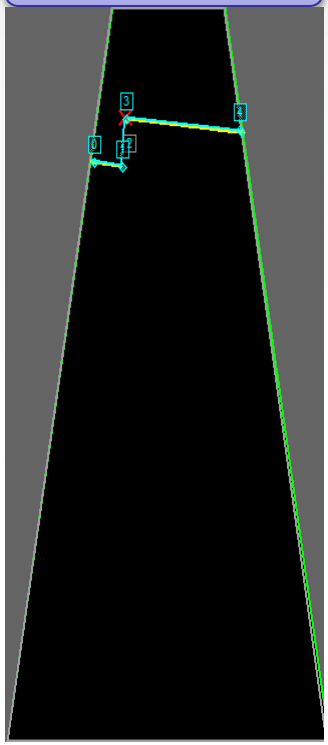
Pair 3 Point 1



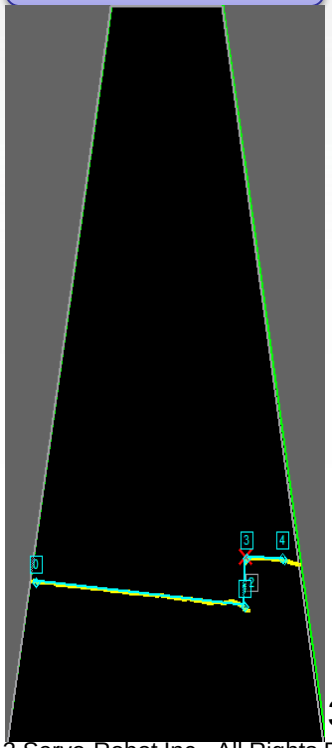
Pair 3 Point 2



Pair 4 Point 1



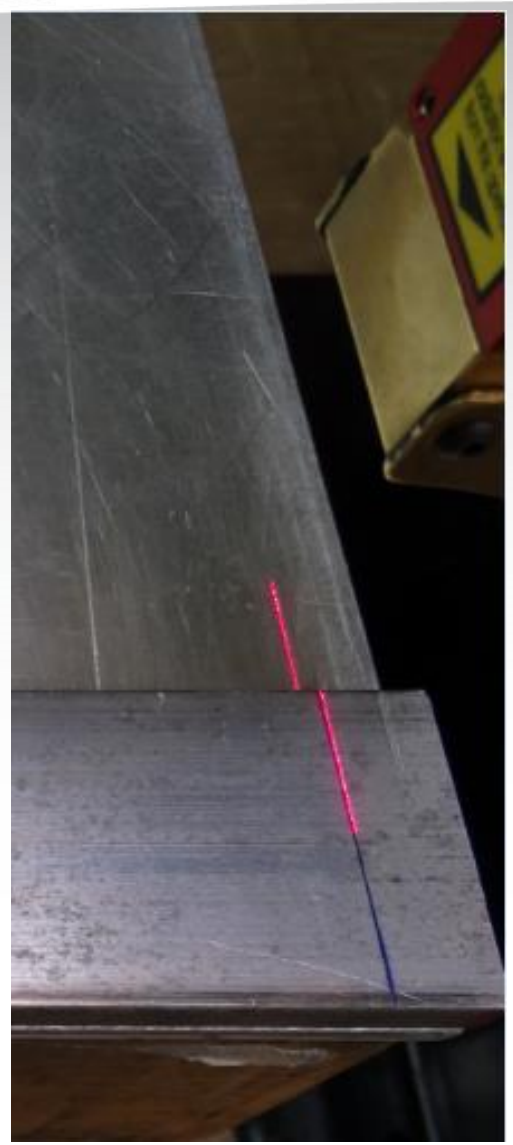
Pair 4 Point 2



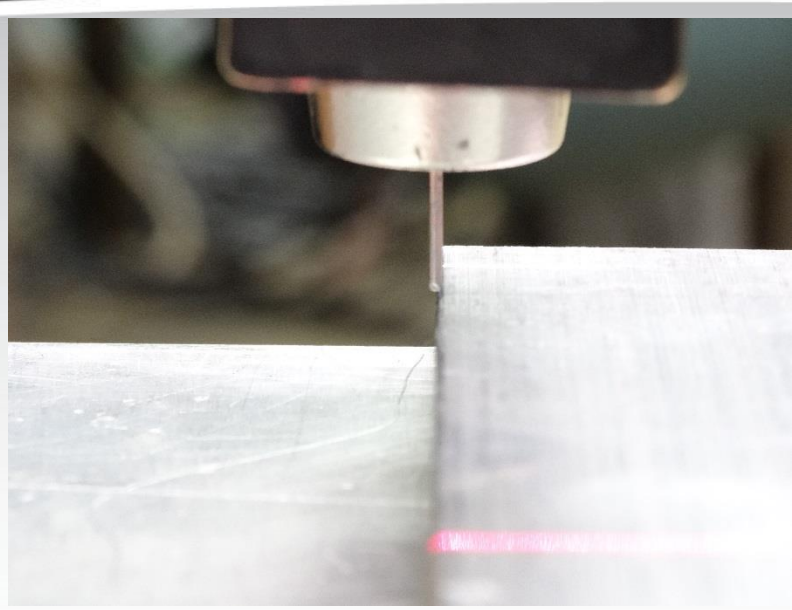
Ten Point Calibration

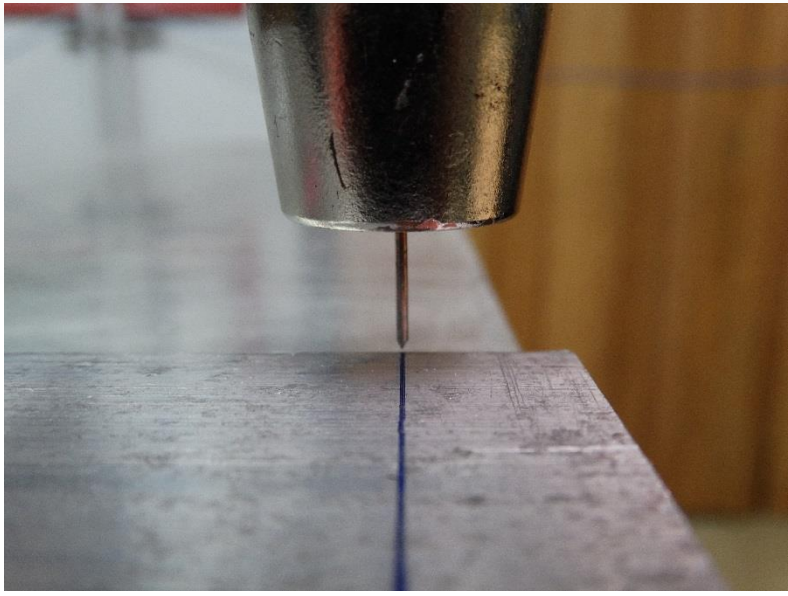
Position Camera Over Joint

- Connect to WeldCom with a computer and turn on the laser.
- Position the robot so the laser stripe lines up with Reference Point 1.
- From here move the robot in WORLD cord. until the TCP reaches Reference Point 1.



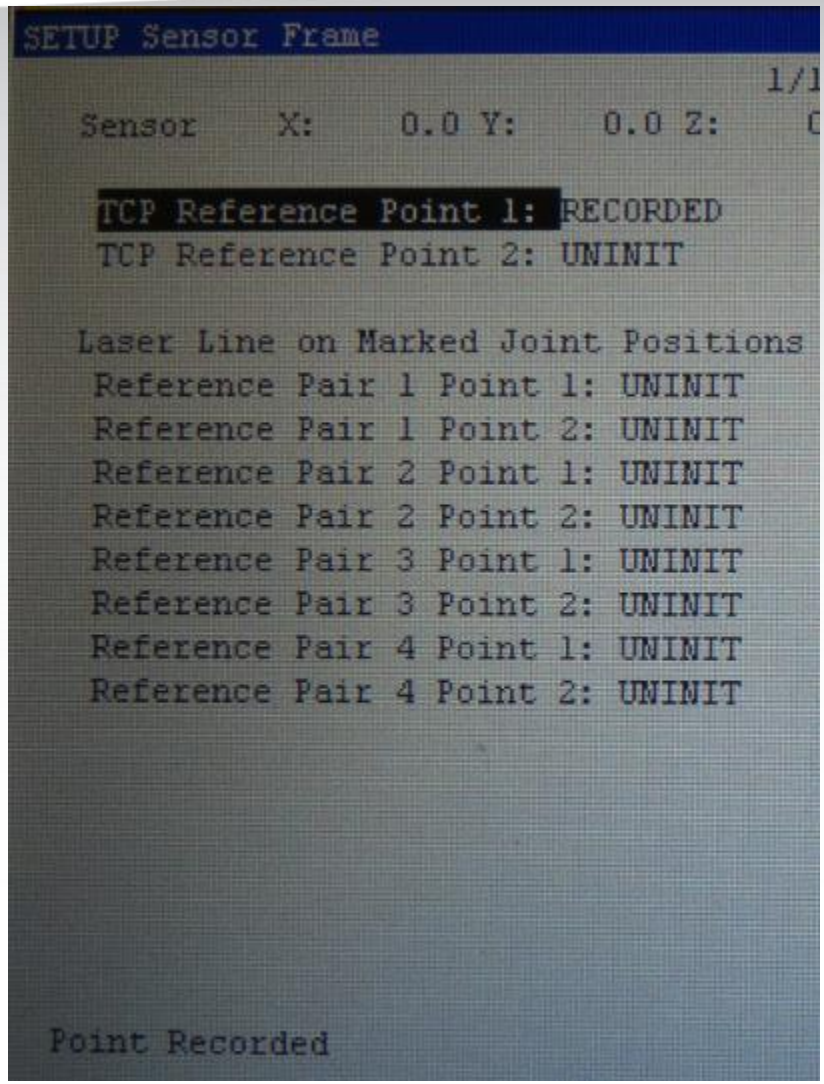
TCP Reference Point 1



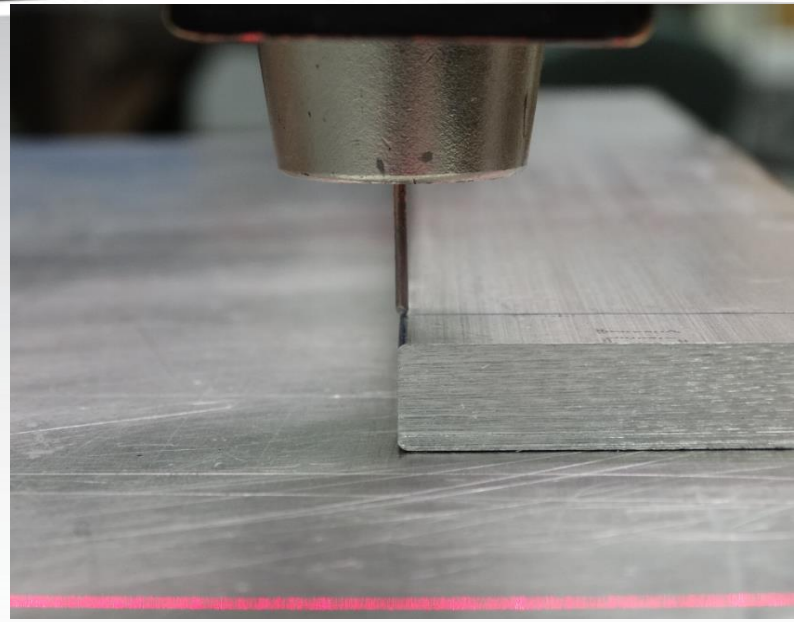


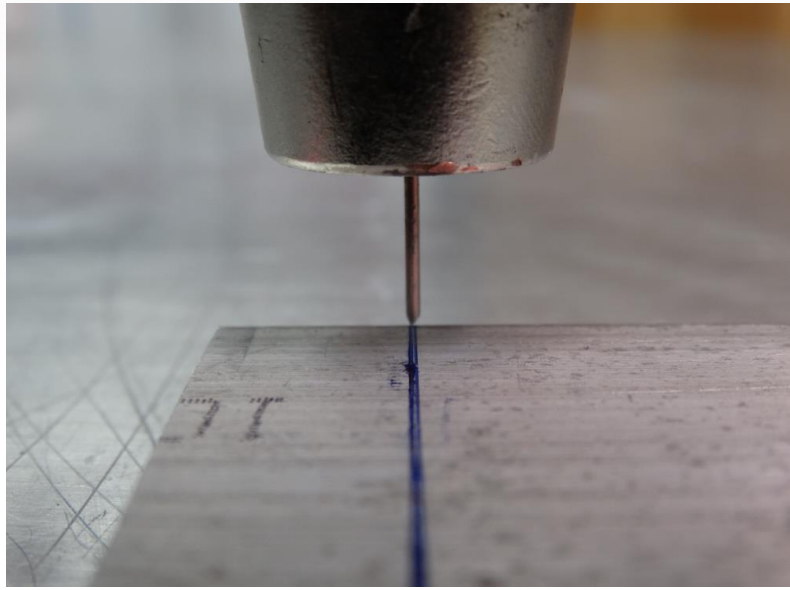
TCP Reference Point 1 - Continued

- When the TCP is in position cursor to “TCP Reference Point 1”.
- While holding the Shift key press Record(F5)
- TCP Reference Point 1 is now recorded.
- In WORLD cord. using only X(J1), Y(J2), & Z(J3) move the robot to Reference Point 2.



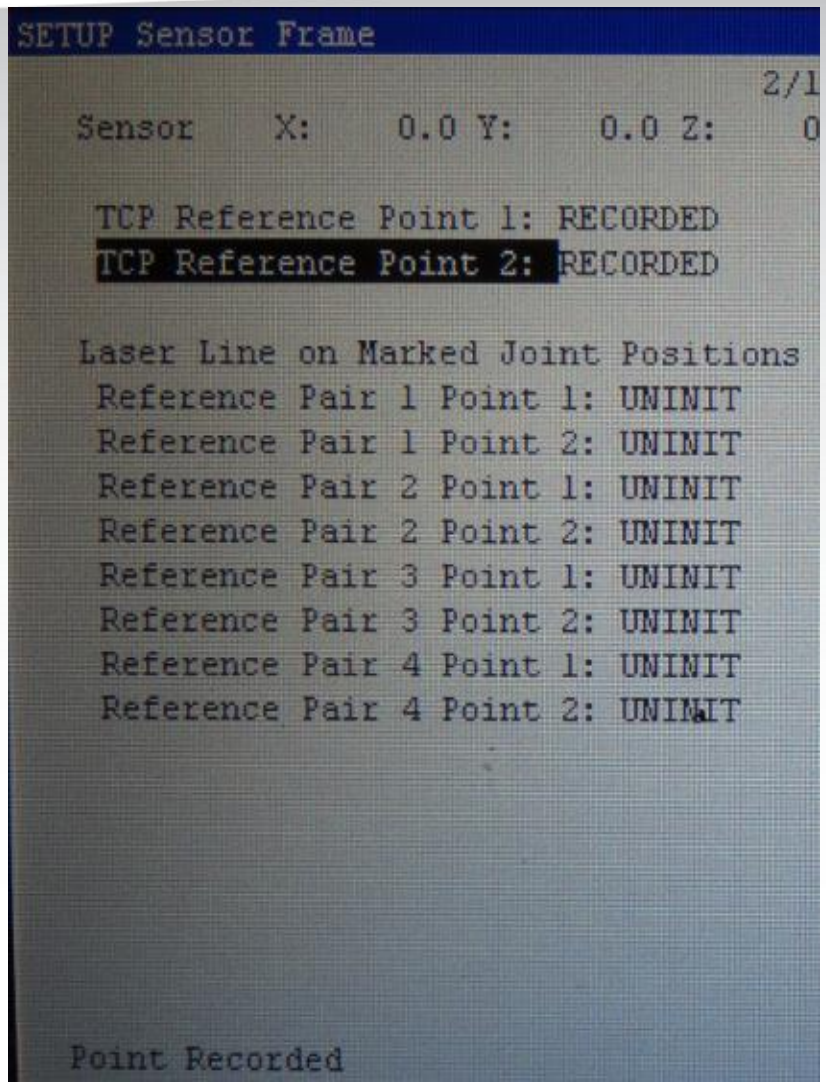
TCP Reference Point 2



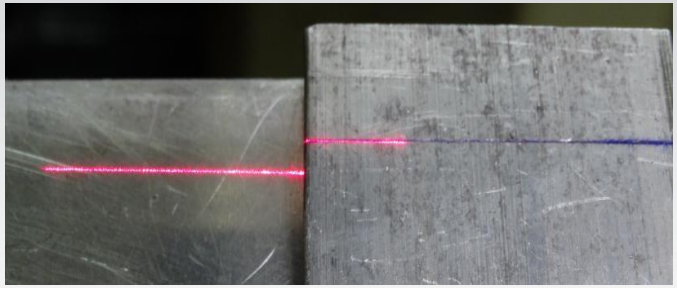


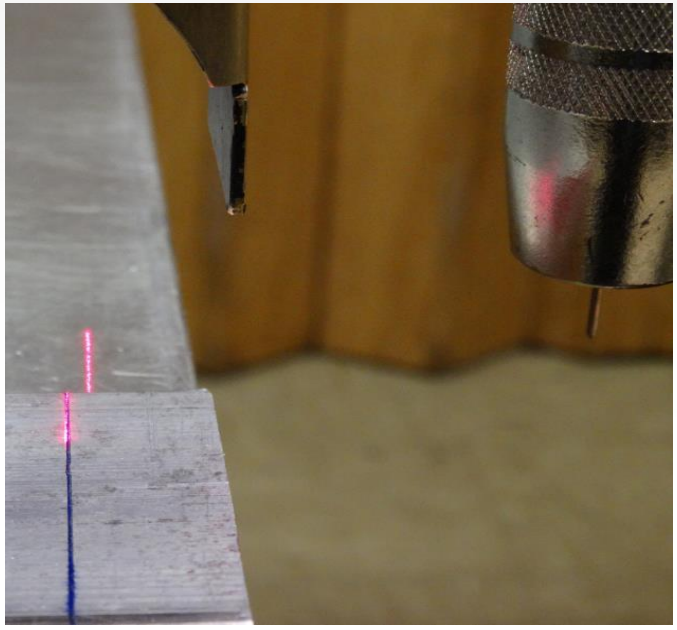
TCP Reference Point 2 - Continued

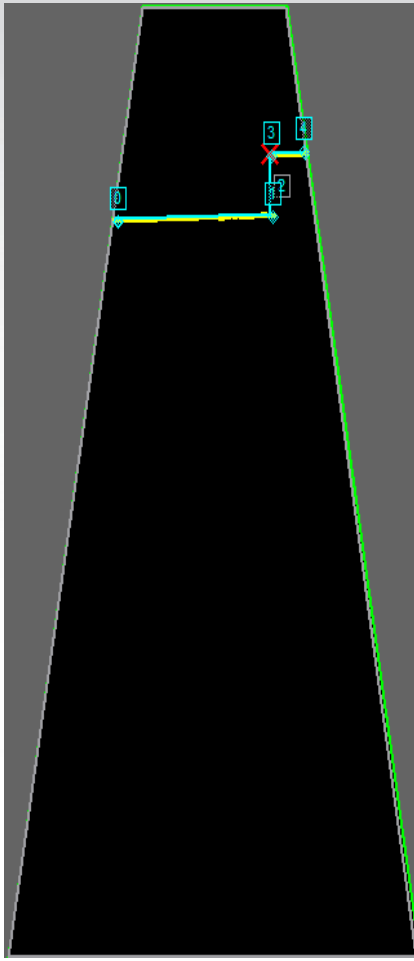
- When the TCP is in position cursor to “TCP Reference Point 2”.
- While holding the Shift key press Record(F5)
- TCP Reference Point 2 is now recorded.
- Cursor up to “TCP Reference Point 1”.
- While holding the Deadman switch and Shift key, press Move To(F4).



Reference Pair 1 Point 1

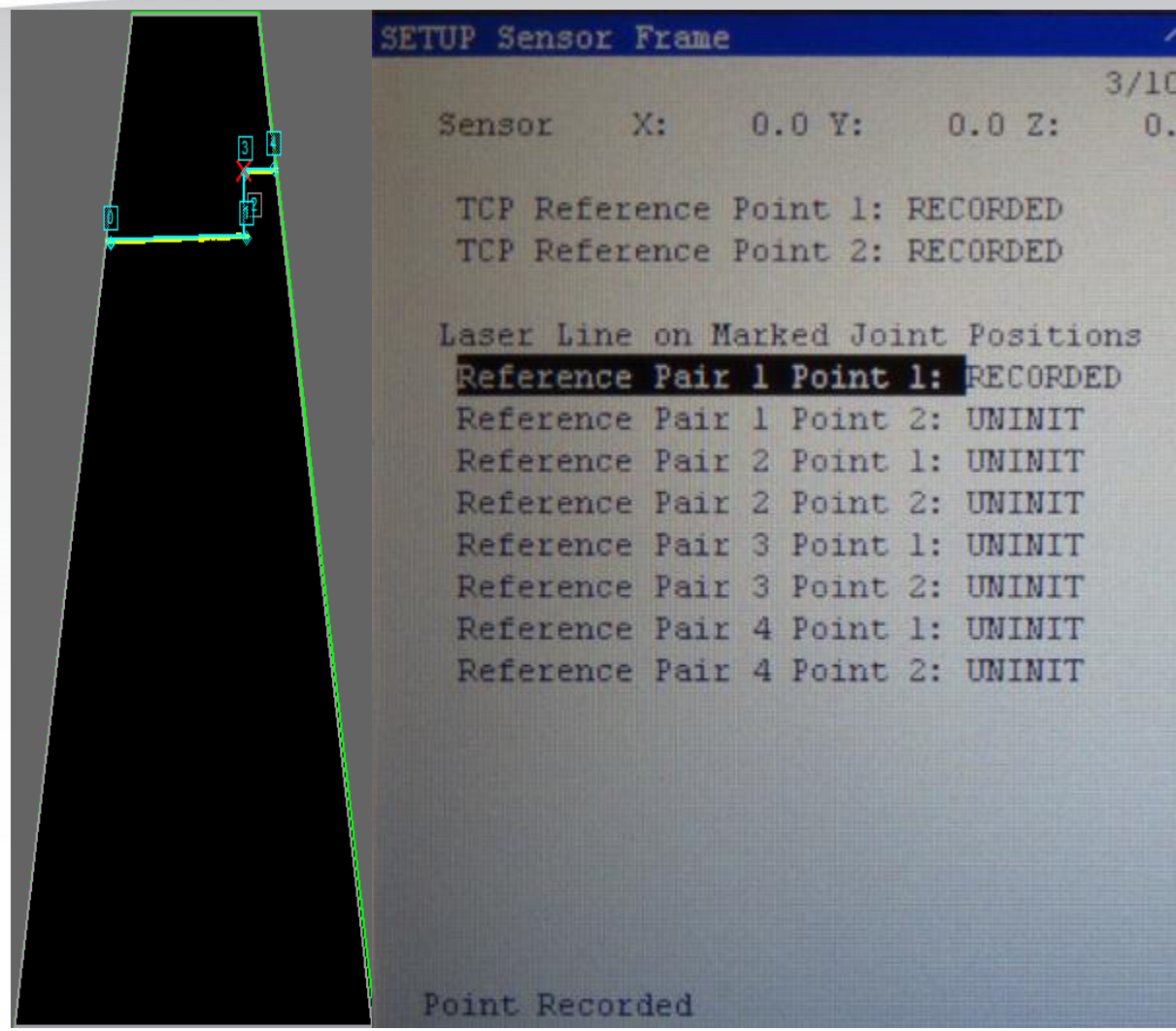




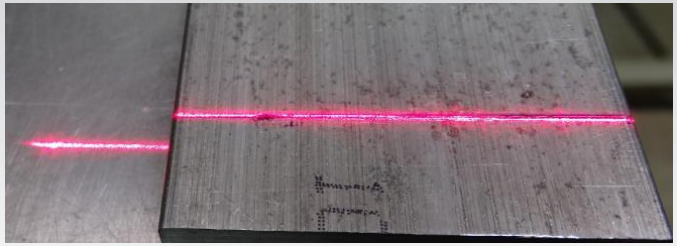


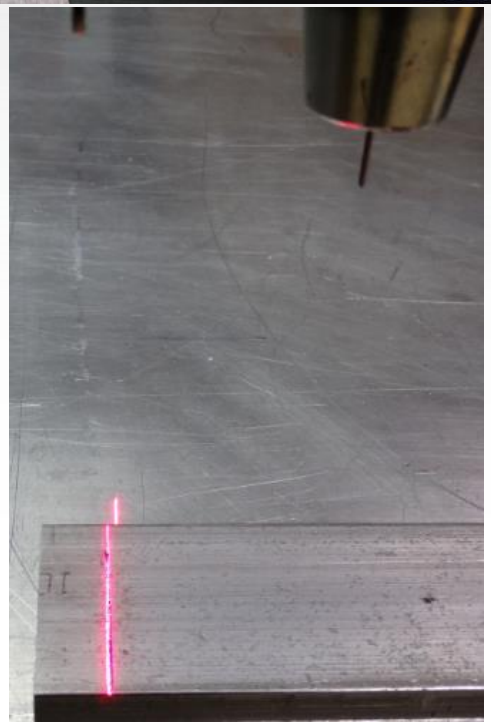
Reference Pair 1 Point 1 - Continued

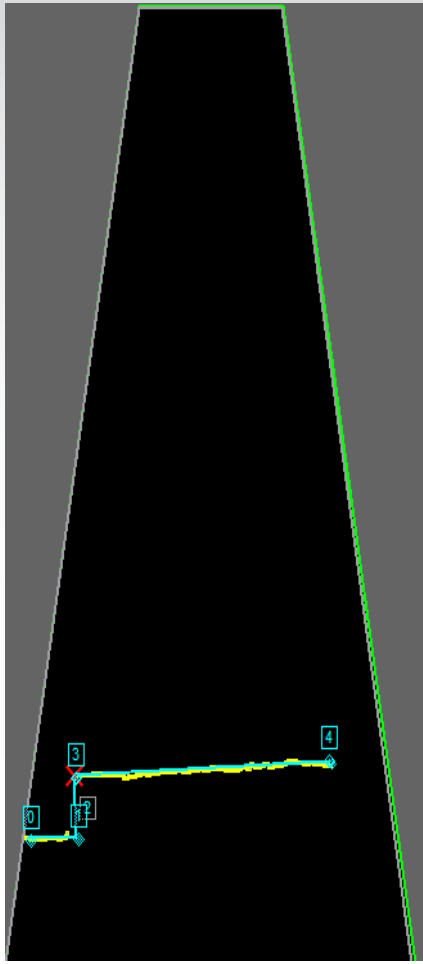
- In WORLD cord. move the robot using X(J1), Y(J2), & Z(J3) so the joint is in the top right corner of the WeldCom screen.
- Move the Laser Line to Reference Point 1, cursor to “Reference Pair 1 Point 1”.
- While holding the Shift key press Record(F5).
- “Reference Pair 1 Point 1” is now recorded.



Reference Pair 1 Point 2

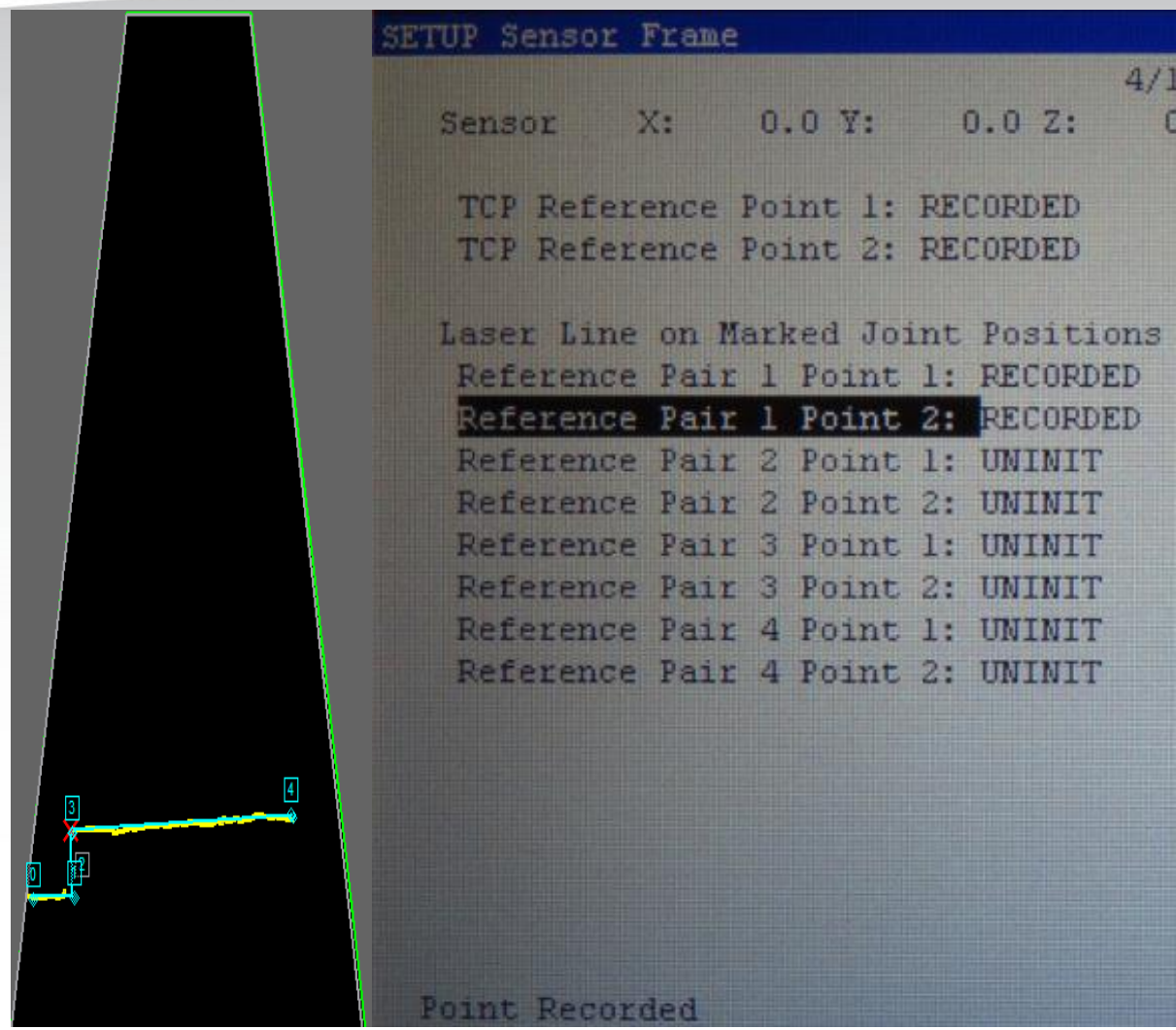




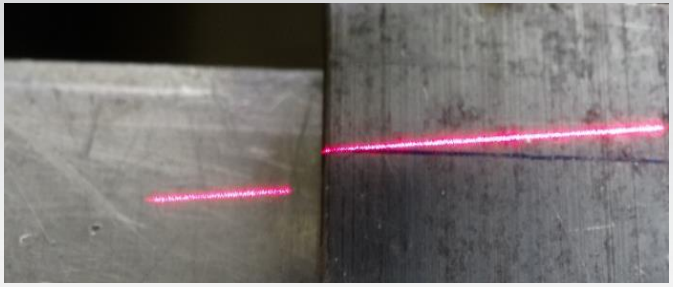


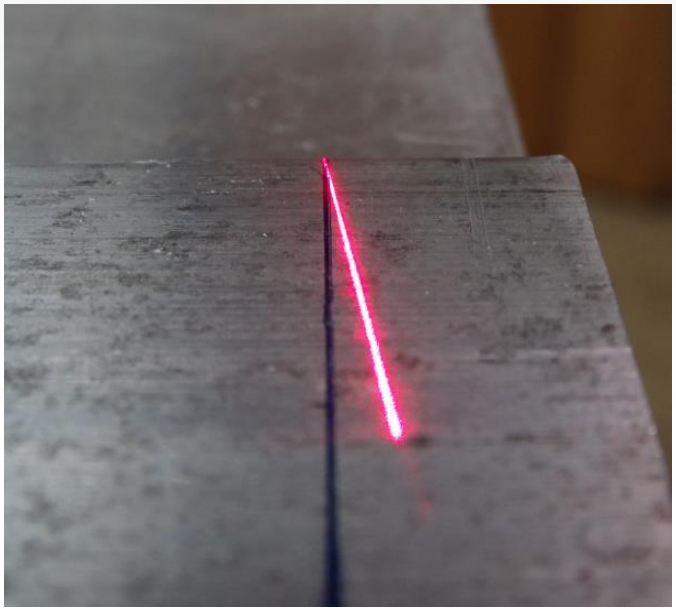
Reference Pair 1 Point 2 - Continued

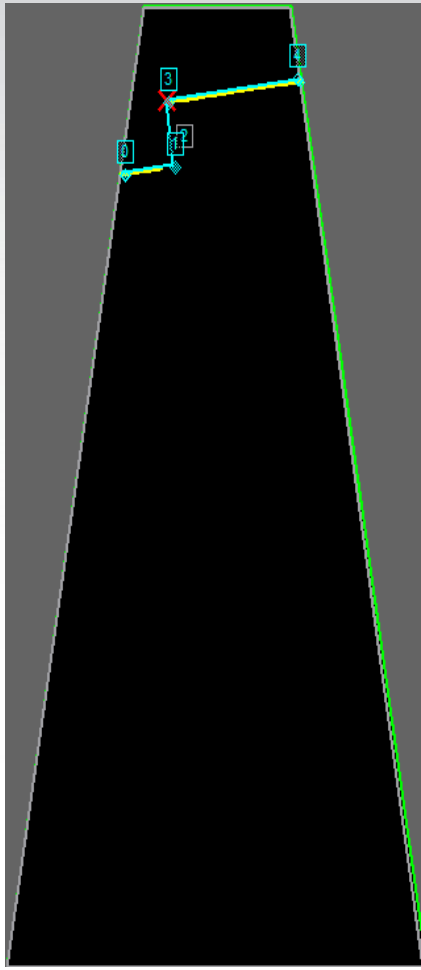
- In WORLD cord. move the robot using X(J1), Y(J2), & Z(J3) so the joint is in the bottom left corner of the WeldCom screen.
- Move the Laser Line to Reference Point 2, cursor to “Reference Pair 1 Point 2”.
- While holding the Shift key press Record(F5).
- “Reference Pair 1 Point 2” is now recorded.
- Cursor to “Reference Pair 1 Point 1”, and while holding the Deadman switch and Shift key press Move To(F4).



Reference Pair 2 Point 1

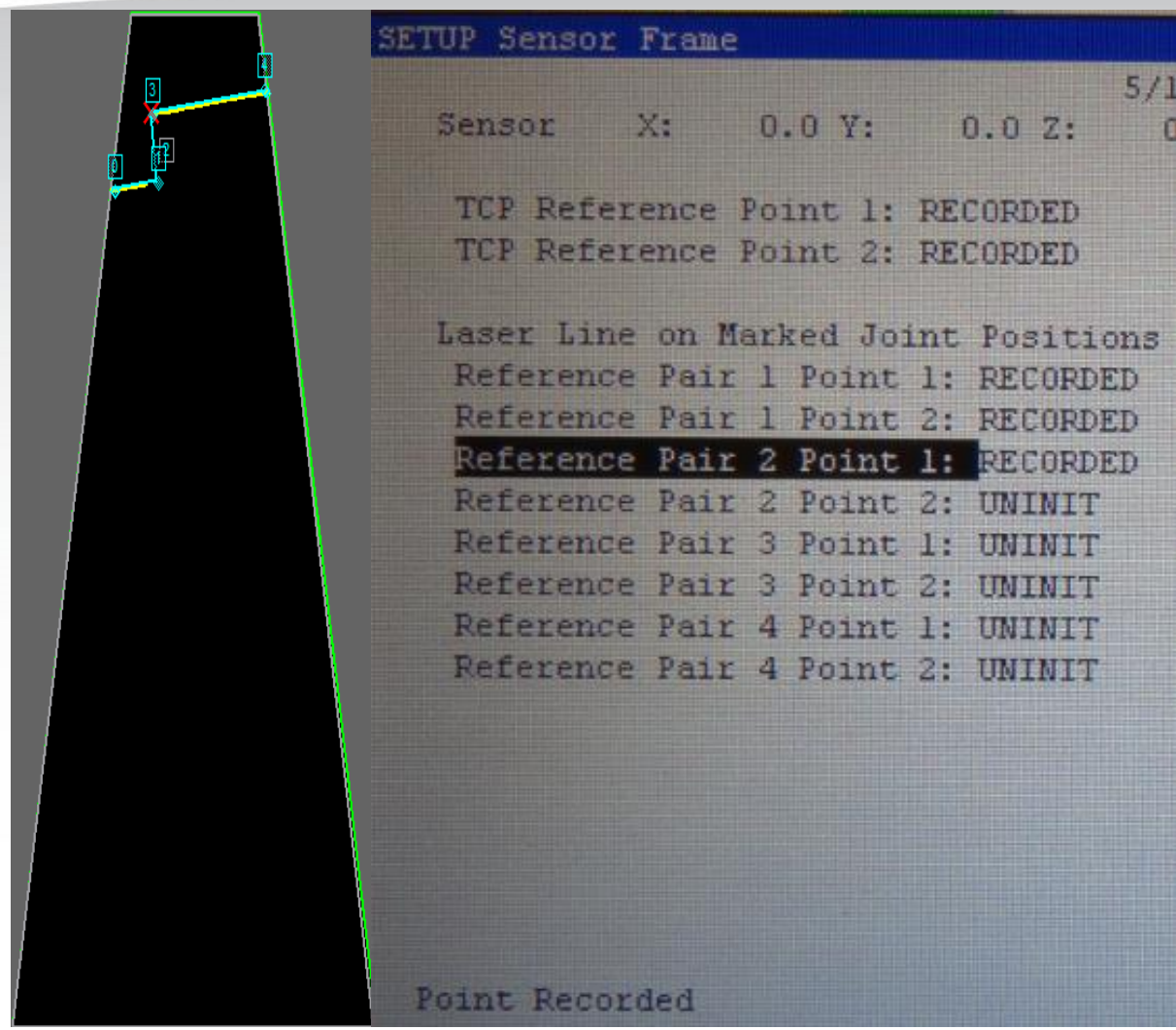




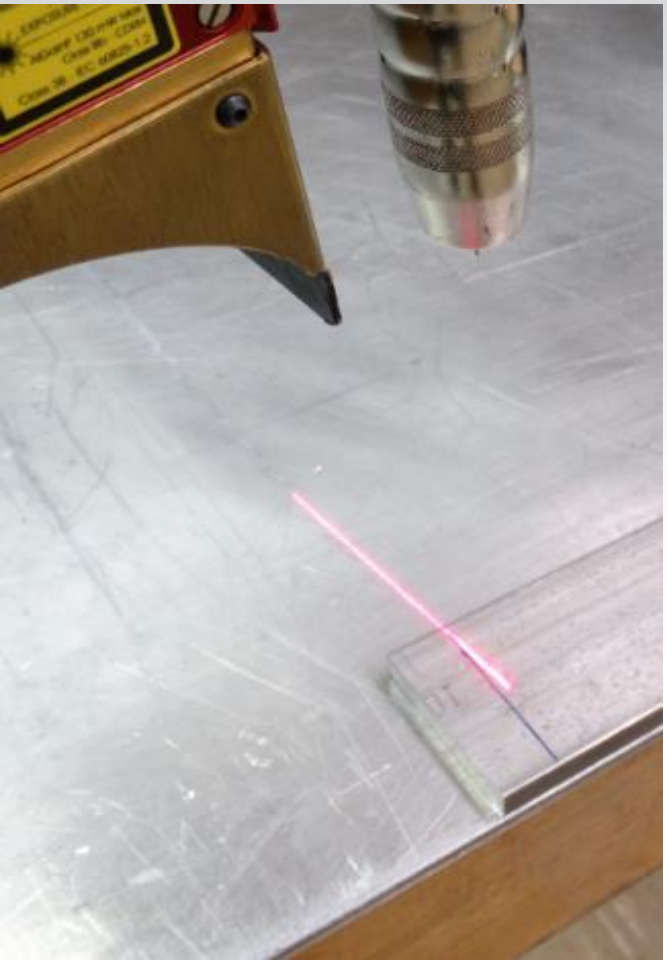


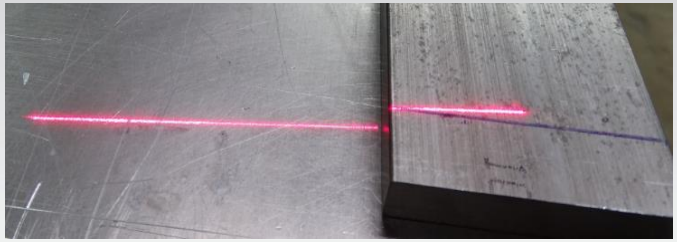
Reference Pair 2 Point 1 - Continued

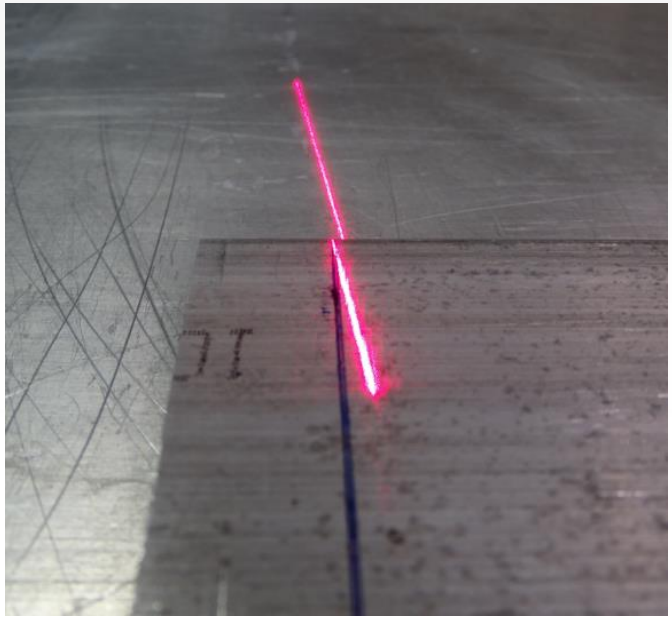
- In TOOL cord. add a positive 5-10^{O} rotation in w(J4), p(J5), & r(J6).
- Switch back to WORLD cord. and move the robot so the joint is in the top left corner of the WeldCom screen.
- Move the Laser Line to Reference Point 1, cursor to “Reference Pair 2 Point 1”.
- While holding the Shift key press Record(F5).
- “Reference Pair 2 Point 1” is now recorded.

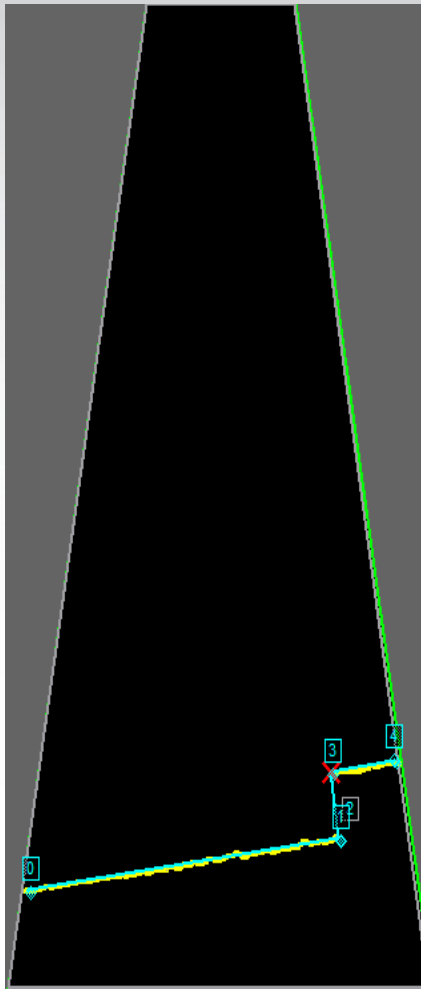


Reference Pair 2 Point 2



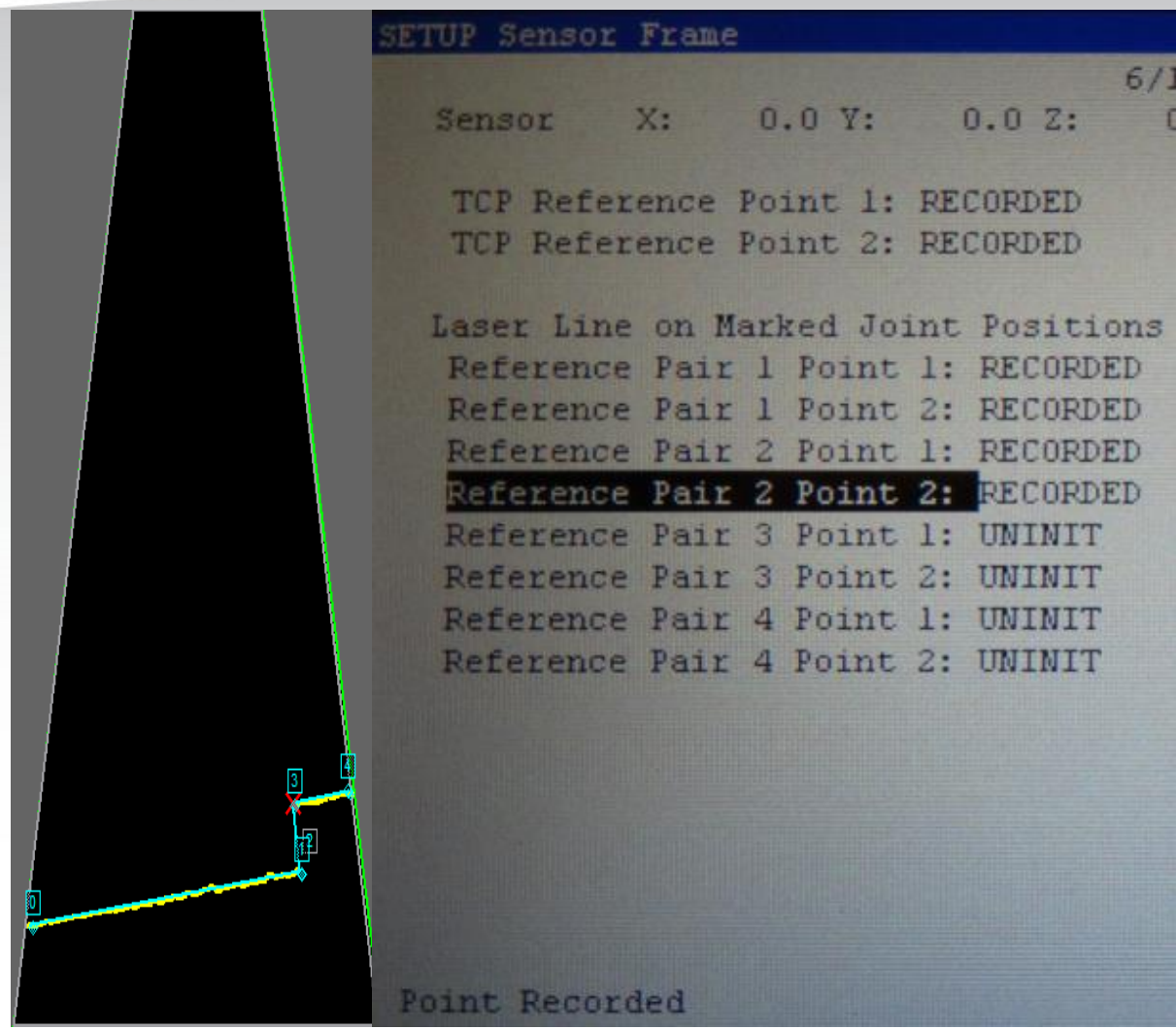




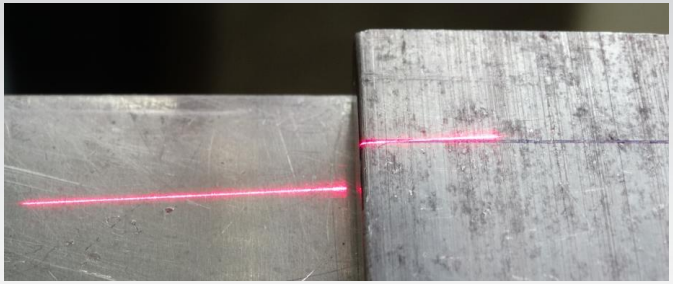


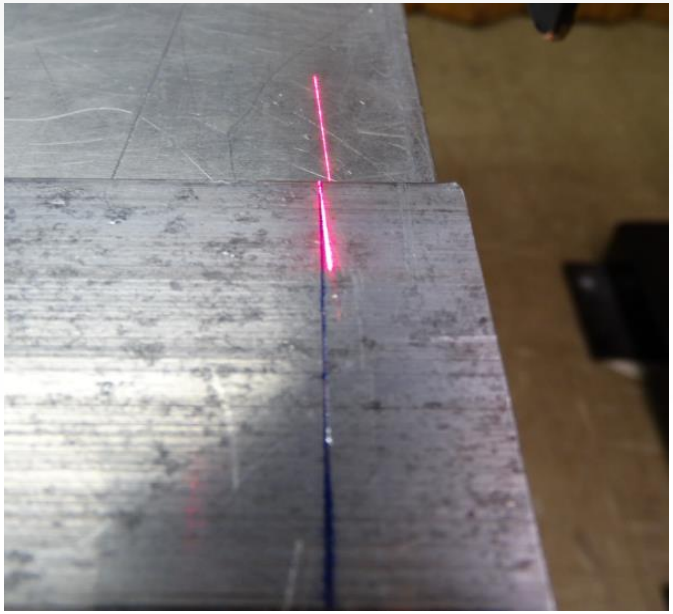
Reference Pair 2 Point 2 - Continued

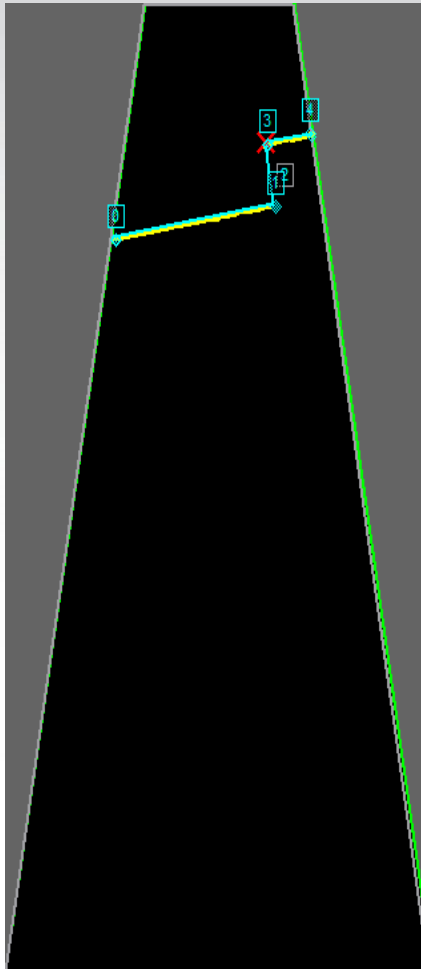
- In WORLD cord. move the robot using X(J1), Y(J2), & Z(J3) so the joint is in the bottom right corner of the WeldCom screen.
- Move the Laser Line to Reference Point 2, cursor to “Reference Pair 2 Point 2”.
- While holding the Shift key press Record(F5).
- “Reference Pair 2 Point 2” is now recorded.
- Cursor to “Reference Pair 1 Point 1”, and while holding the Deadman switch and Shift key press Move To(F4).



Reference Pair 3 Point 1

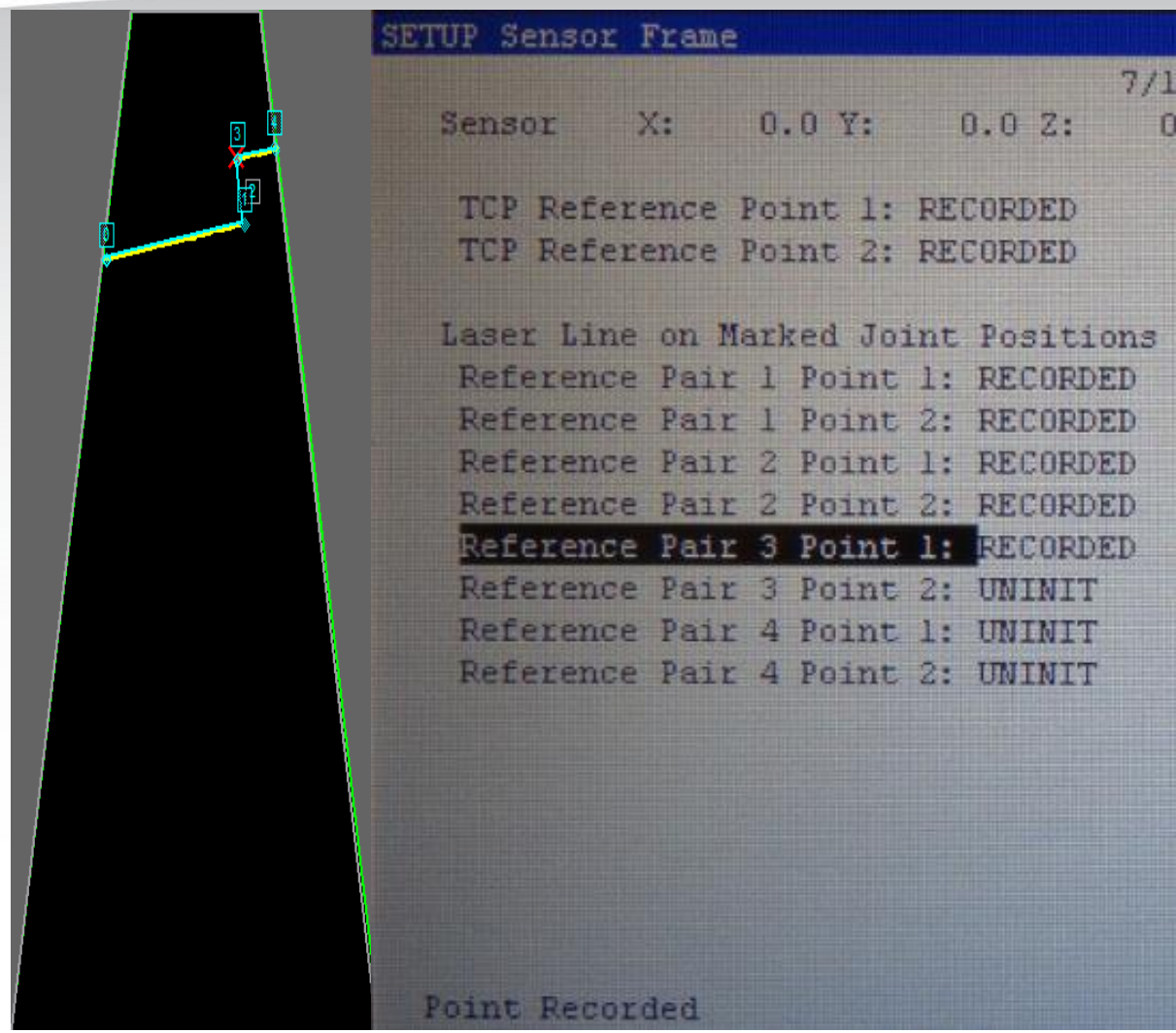




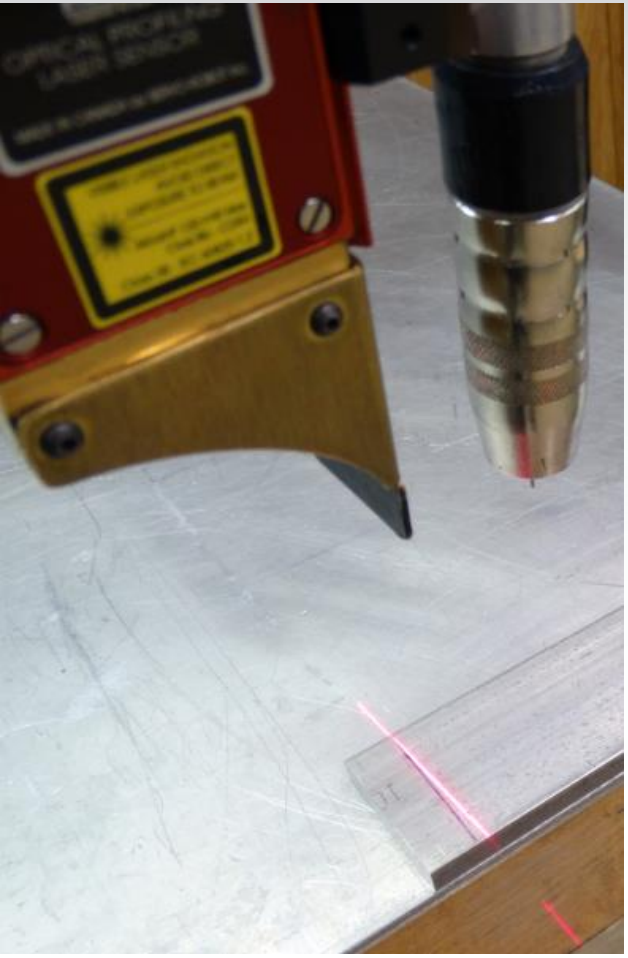


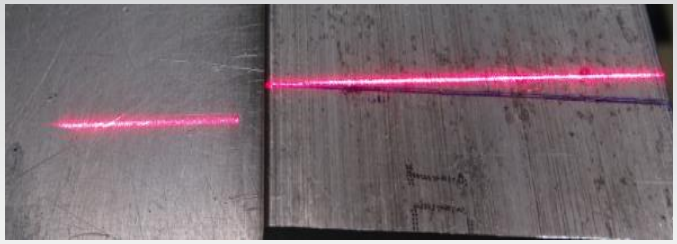
Reference Pair 3 Point 1 - Continued

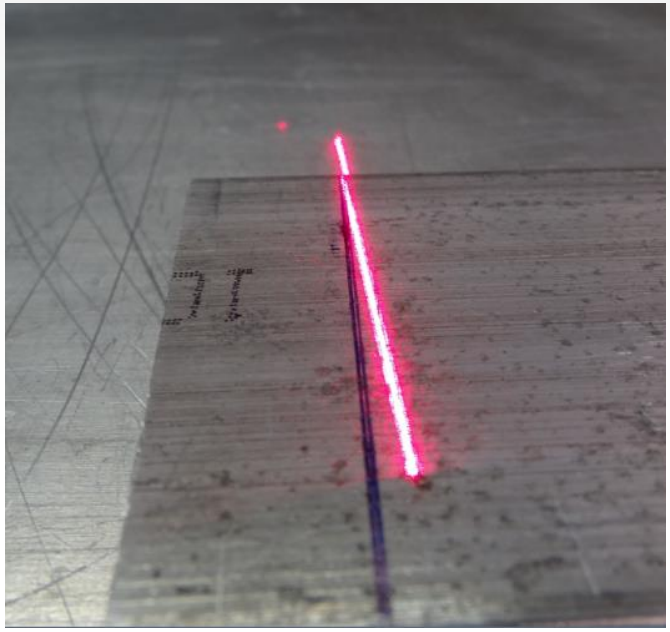
- In TOOL cord. add a positive 5-10^{O} rotation in p(J5) & r(J6).
- Switch back to WORLD cord. and move the robot so the joint is in the top right corner of the WeldCom screen.
- Move the Laser Line to Reference Point 1, cursor to “Reference Pair 3 Point 1”.
- While holding the Shift key press Record(F5).
- “Reference Pair 3 Point 1” is now recorded.

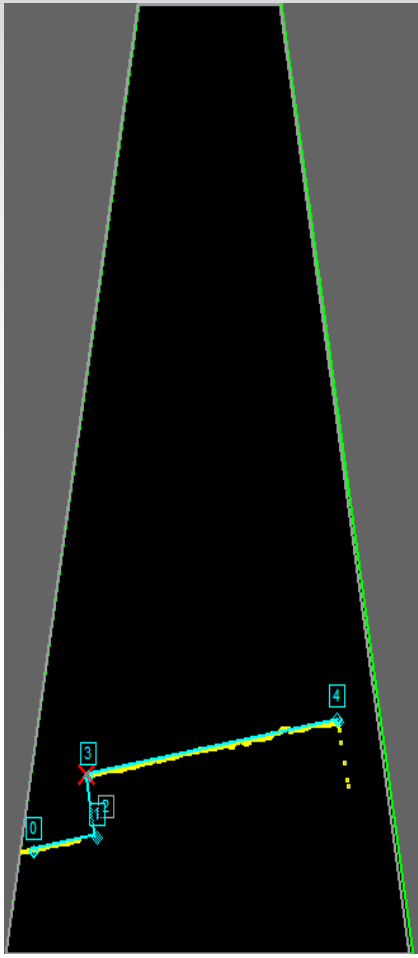


Reference Pair 3 Point 2



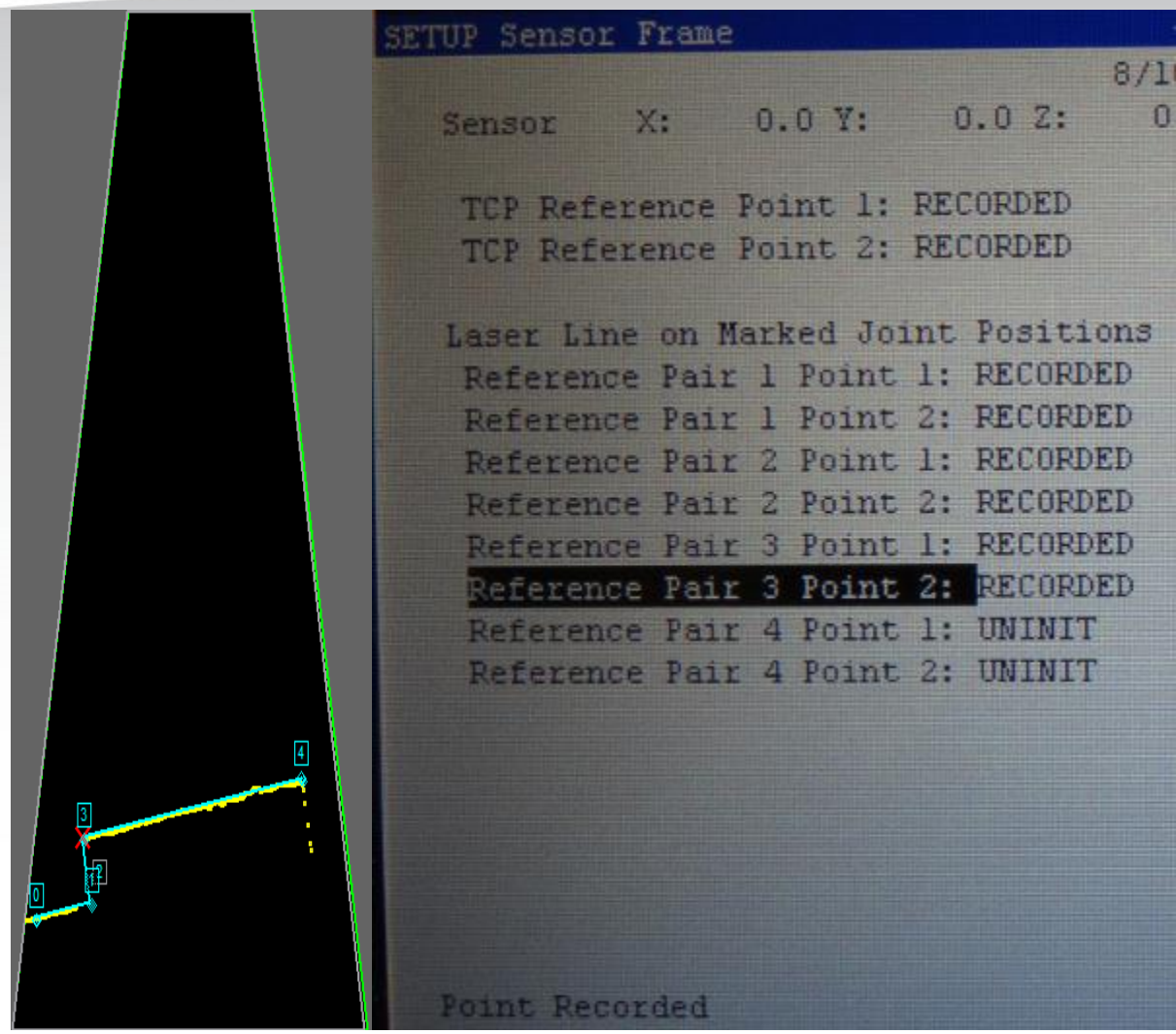




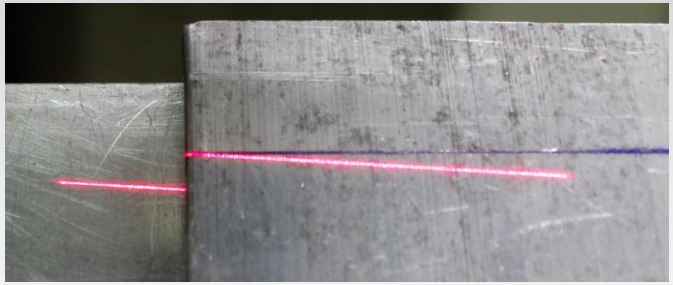


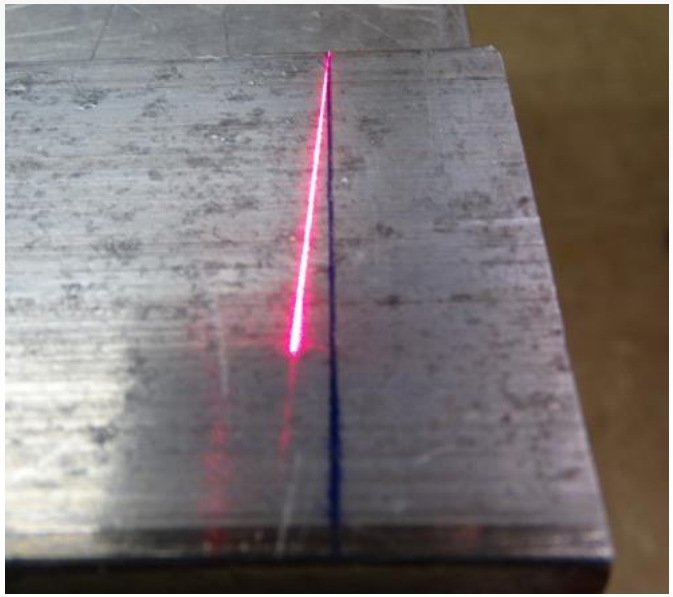
Reference Pair 3 Point 2 - Continued

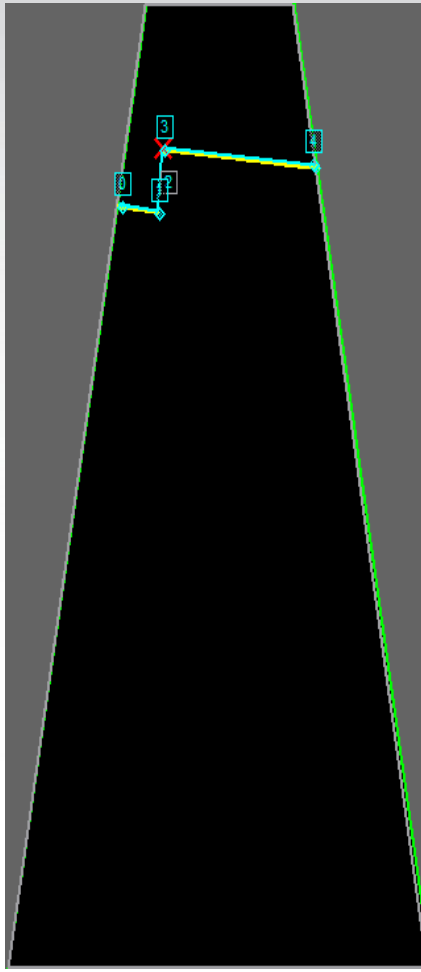
- In WORLD cord. move the robot using X(J1), Y(J2), & Z(J3) so the joint is in the bottom left corner of the WeldCom screen.
- Move the Laser Line to Reference Point 2, cursor to “Reference Pair 3 Point 2”.
- While holding the Shift key press Record(F5).
- “Reference Pair 3 Point 2” is now recorded.
- Cursor to “Reference Pair 1 Point 1”, and while holding the Deadman switch and Shift key press Move To(F4).



Reference Pair 4 Point 1

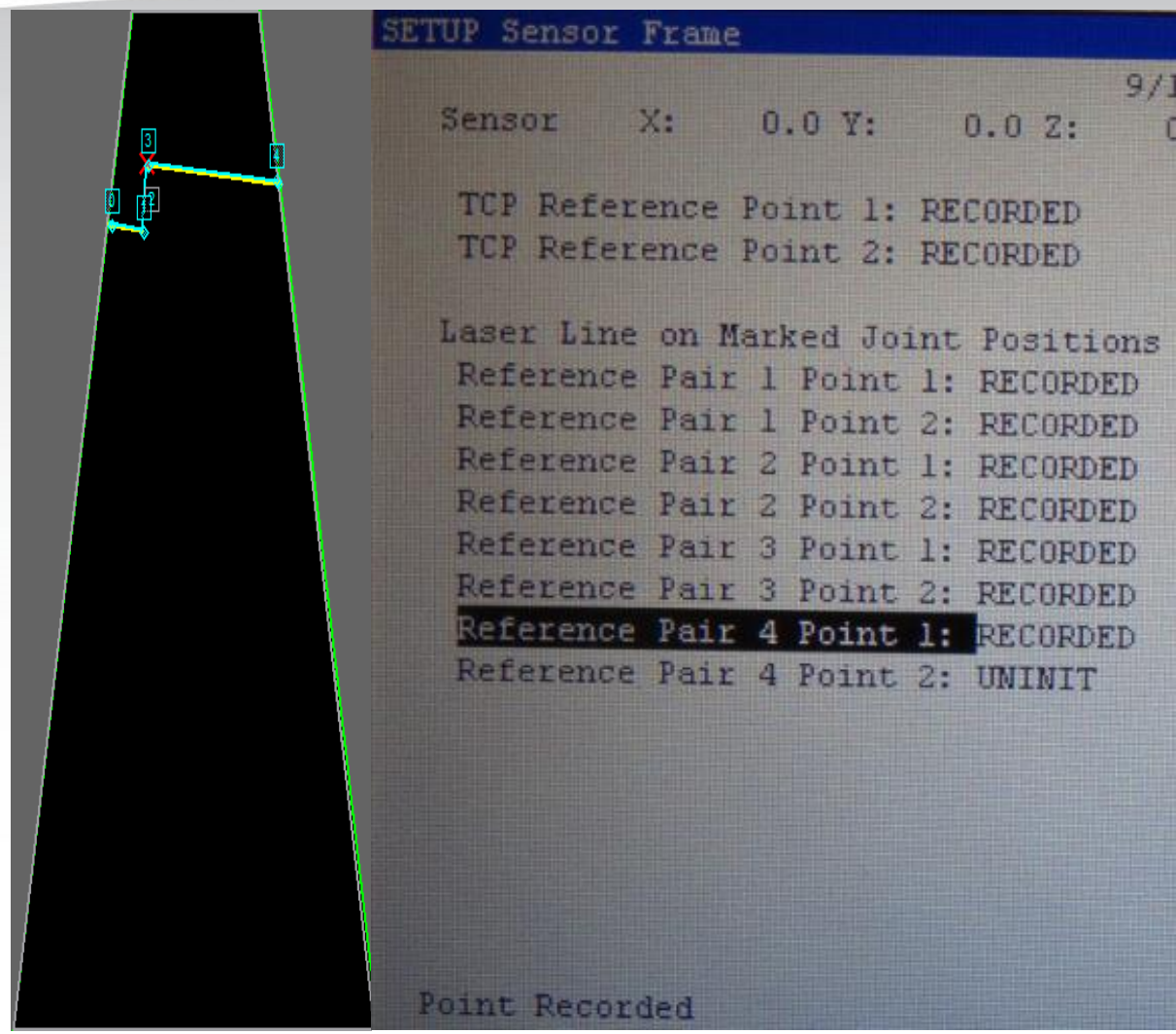




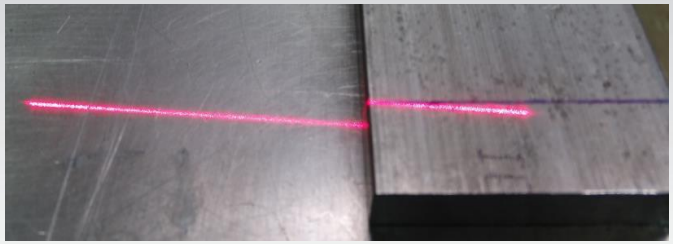


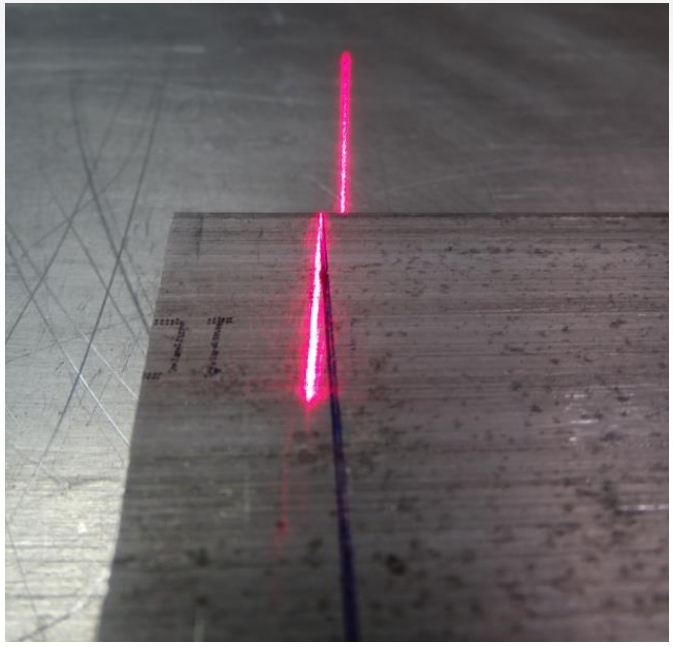
Reference Pair 4 Point 1 - Continued

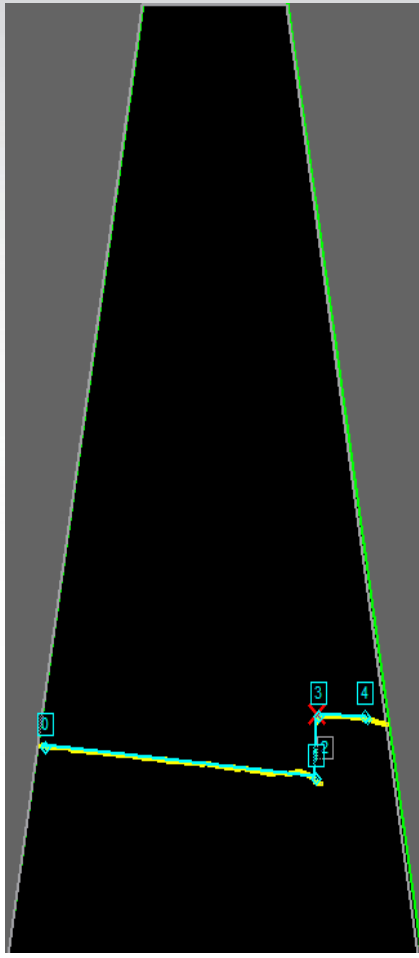
- In TOOL cord. add a negative 5-10^{O} rotation in p(J5) & r(J6).
- Switch back to WORLD cord. and move the robot so the joint is in the top right corner of the WeldCom screen.
- Move the Laser Line to Reference Point 1, cursor to “Reference Pair 4 Point 1”.
- While holding the Shift key press Record(F5).
- “Reference Pair 4 Point 1” is now recorded.



Reference Pair 4 Point 2

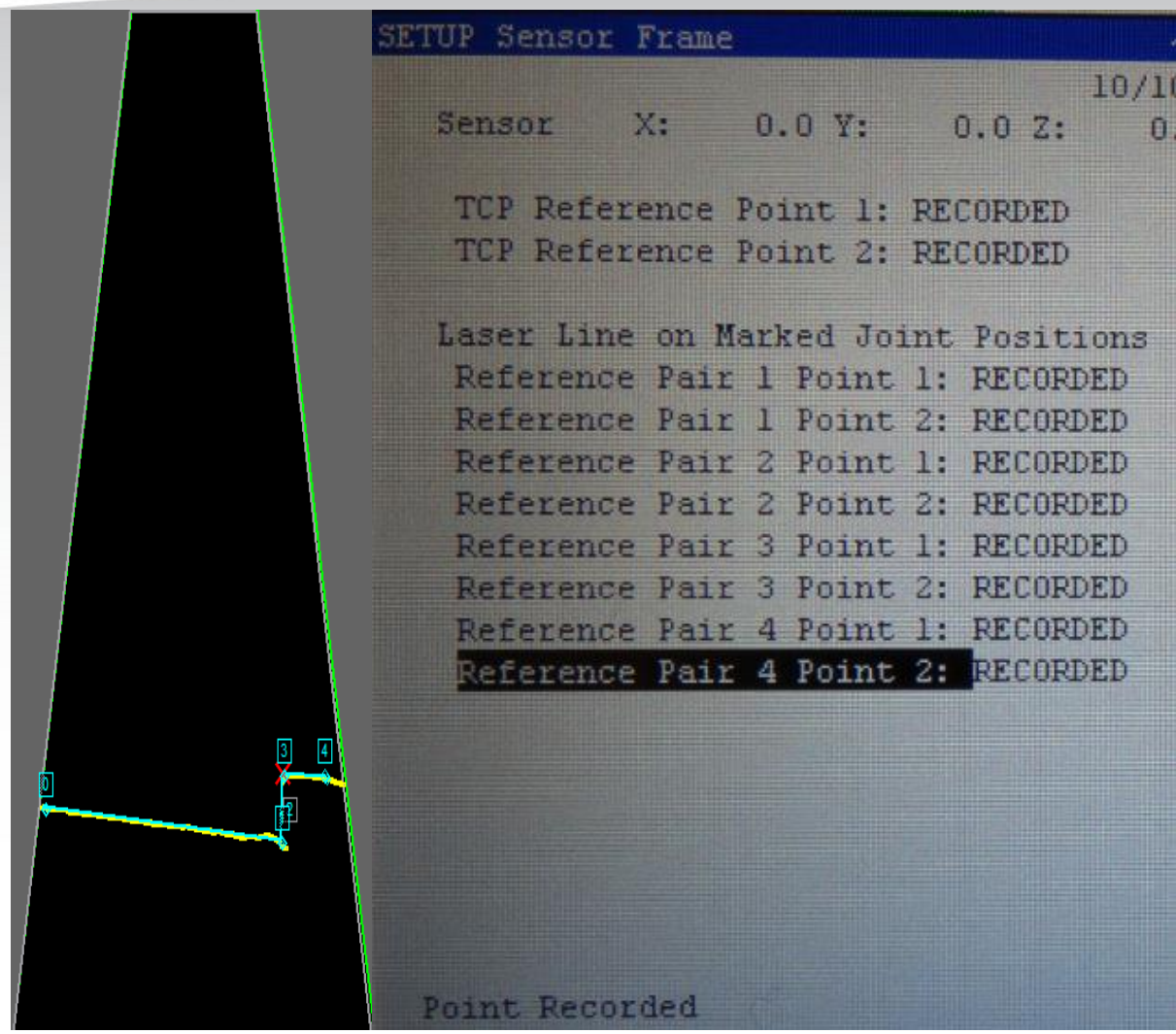






Reference Pair 4 Point 2 - Continued

- In WORLD cord. move the robot using X(J1), Y(J2), & Z(J3) so the joint is in the bottom right corner of the WeldCom screen.
- Move the Laser Line to Reference Point 2, cursor to “Reference Pair 4 Point 2”.
- While holding the Shift key press Record(F5).
- “Reference Pair 4 Point 2” is now recorded.

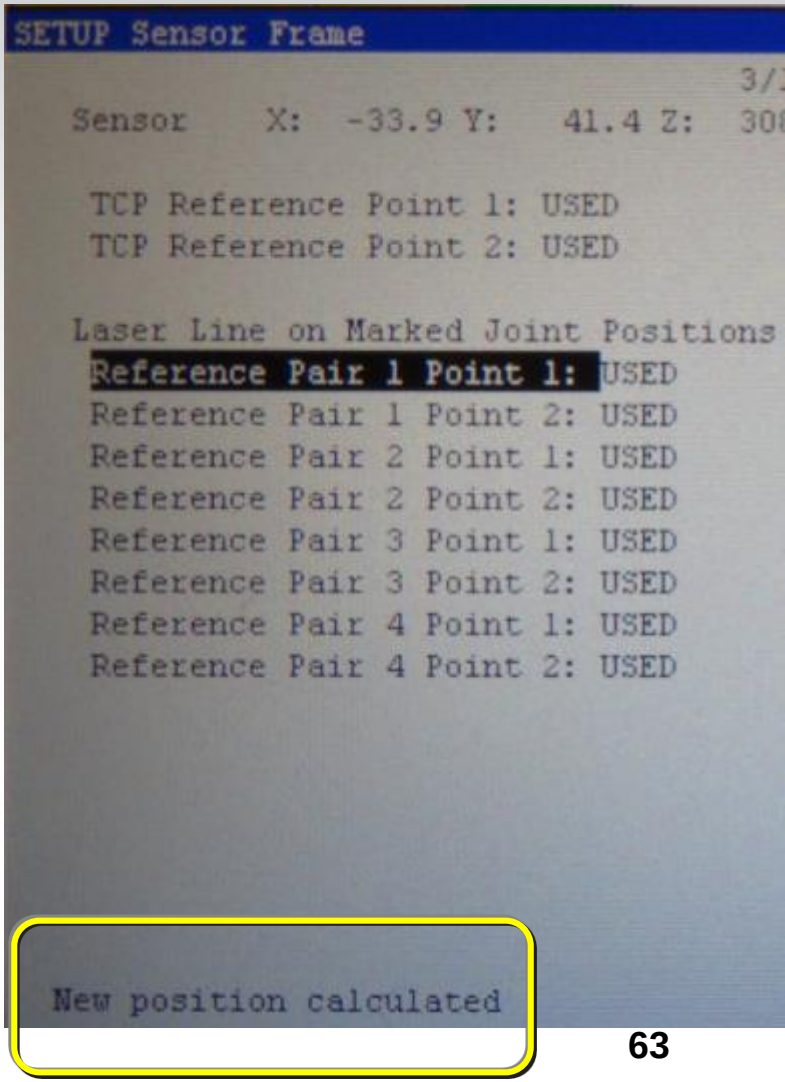


Calibration Routine

- After all 10 points have been recorded the calibration routine needs to be executed. The robot will move automatically through your taught points starting at Pair 1 Point 1.
- If this is your first time running this sequence a jogging speed of 50% or less is recommended.
- Note: The jogging speed can be increased to 100% if you've done this sequence before and know for certain that the robot will not crash into any fixturing or the calibration plate itself.

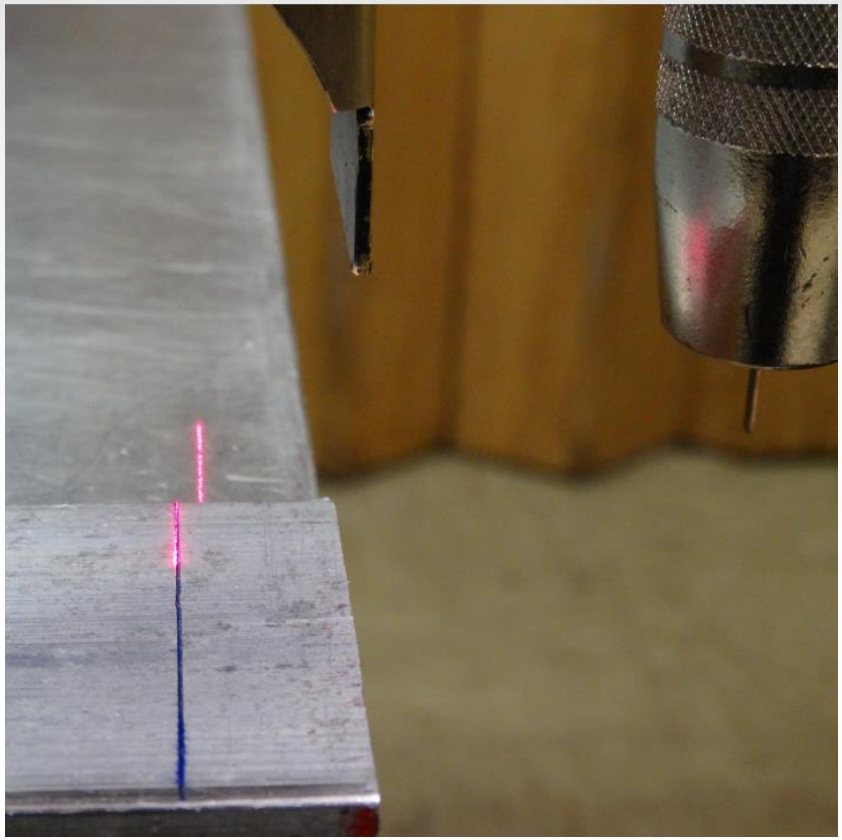
Execute Calibration Routine

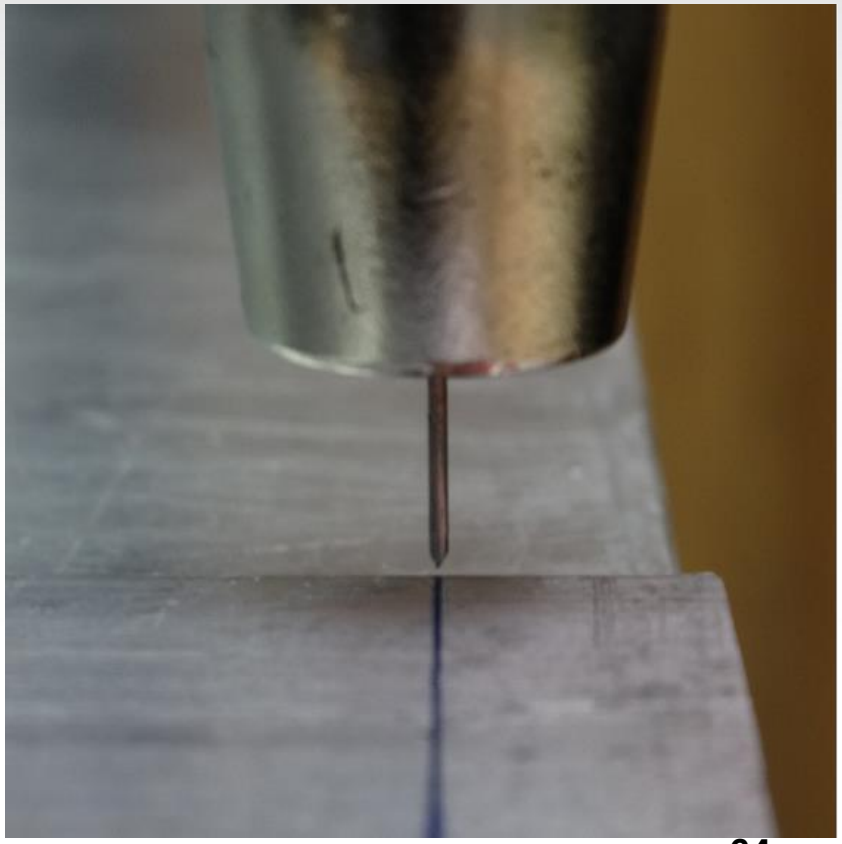
- Cursor to “Reference Pair 1 Point 1”, and while holding the Deadman switch and Shift key press Move To(F4).
- Hold down the Deadman switch and Shift key and press EXEC(F3). The robot will automatically run the calibration routine.
- After the calibration routine is done and was calibrated successfully, you will get a message at the bottom of the teach pendant saying “New position calculated”.
- Note: If you get a message at the bottom of the teach pendant saying “Pair 1, 2, 3, or 4 do not match”, you must correct and rerecord that Pair and execute the calibration routine again.



Verify the Sensor Frame

To verify the Sensor Frame we will move to a known position, run a program to search said position, and using Position Register 1, move the TCP to that searched point.

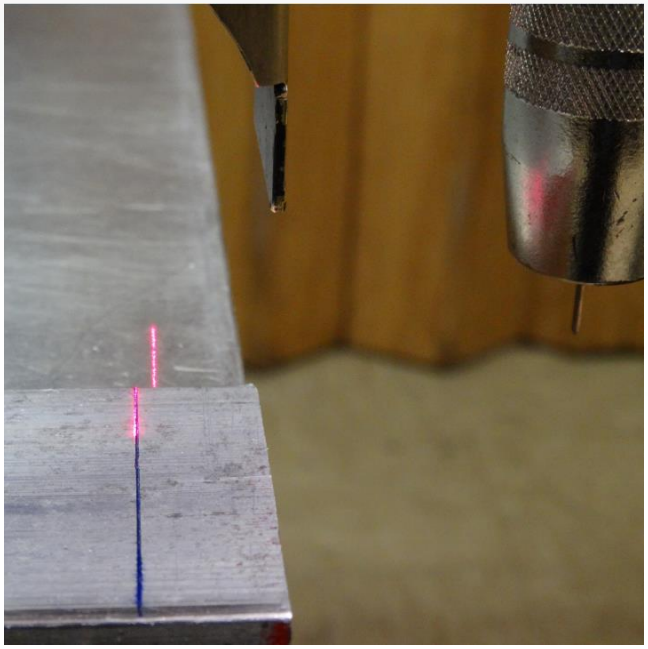


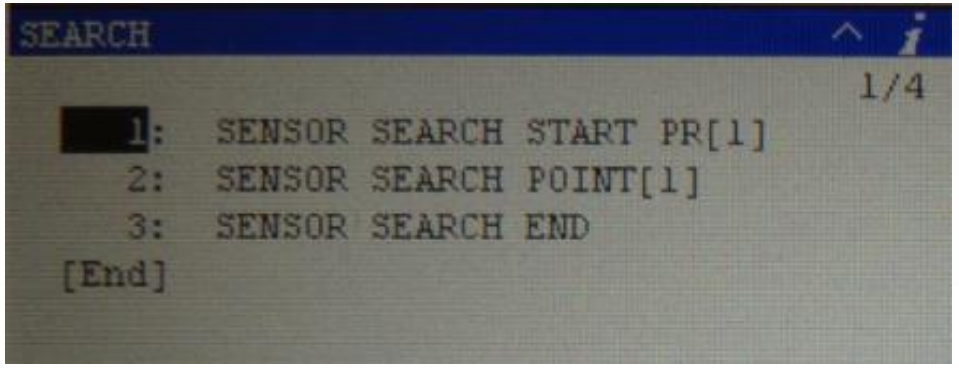


Verify the Sensor Frame - Continued

- Cursor to “Reference Pair 1 Point 1”, and while holding the Deadman switch and Shift key press Move To(F4).
- From here press:

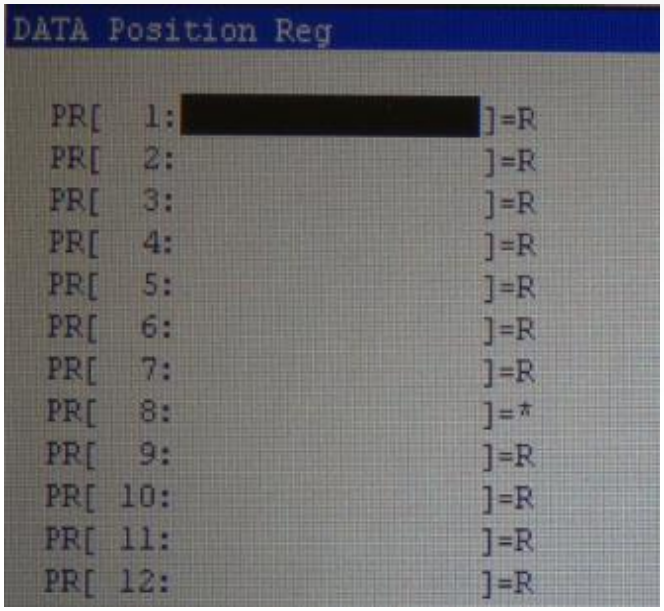
  SELECT → SEARCH → ENTER.
- Run the SEARCH program.

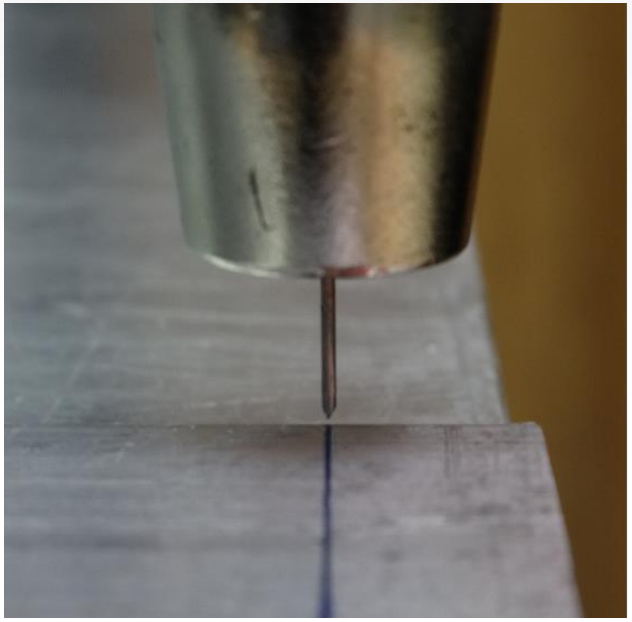




Verify the Sensor Frame - Continued

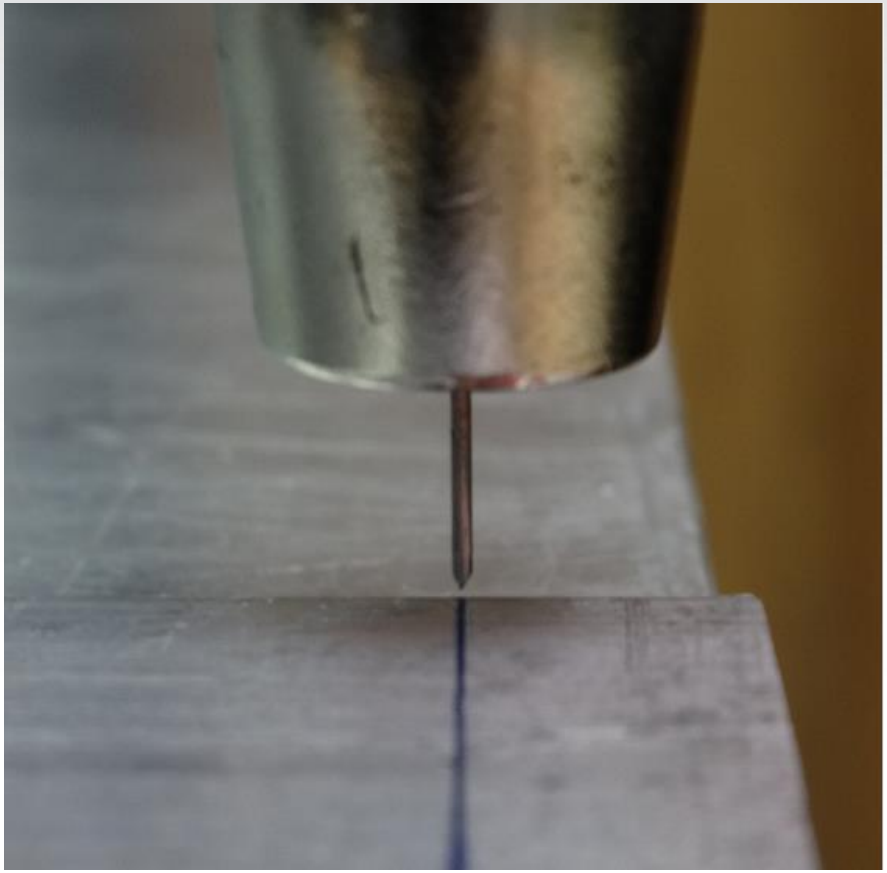
- After the SEARCH program is executed press:
  DATA → TYPE(F1) → Position Reg → ENTER
- Cursor to PR[1], and while holding the Deadman switch and Shift key press:
  MOVE TO(F2)
- The TCP will move to Reference Point 1.





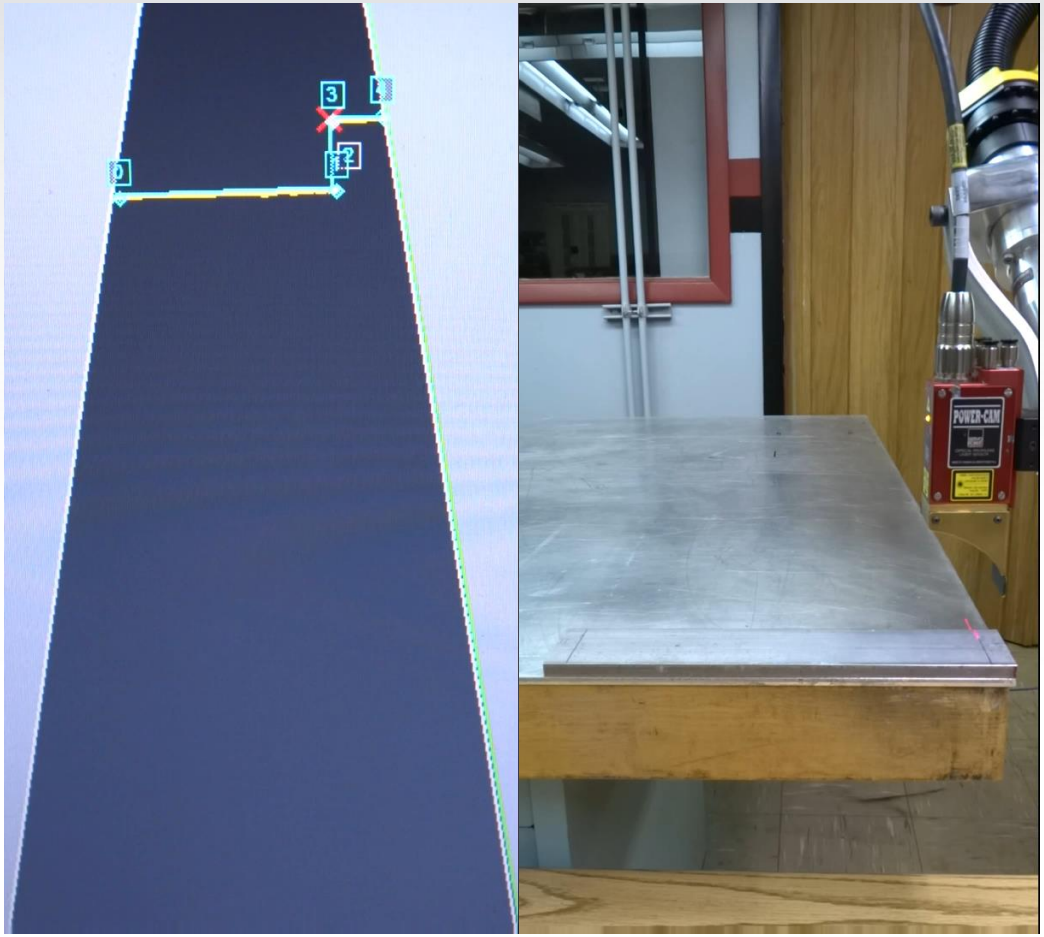
Verify the Sensor Frame - Continued

- The Sensor Frame has now been verified.
- Note: If your TCP is off the reference point by 1 or 2mm you can go into Direct Entry of the Sensor Frame under Method, and modify the X and/or Y position. Before making any changes to the sensor frame you should make a note of the calculated positions. After the changes are made in Direct Entry, run the “Verify the Sensor Frame” routine again to validate whether or not your modifications took effect.



Ten Point Method - Video

Video must be viewed in slide show mode.



End of Document