Technical Information Package

Proper Selection Criteria for Welding Positioners

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NOTICE

The information contained in this document is for reference only. The owners and operators of specific welding equipment should read and understand the equipment's Operation Manual from the manufacturer for all safety and operational procedures. The information contained herein is not designed to replace or contradict any safety or operational information in the manufacturer's Operation Manual. Harris Machine Tools, Inc., including its subsidiaries and divisions, assumes no liability from the use of the information contained in this document. All information is subject to change without notice.

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Introduction

Welding positioners are used to position the work piece such that the weld can be made in the downhand position, for a faster, cleaner and better weld. Without being able to properly position the work piece, the welds may have to be made in a vertical or overhead position that may result in a slower and unsafe welding process, as well as an inferior rate of deposition and a poor quality weld.

There are many types of welding positioners on the market, all designed to tilt and/or rotate the work piece in a manner that the operator may position the welding zone for optimal welding speed and weld quality. Since most positioners not only tilt the work piece, but also rotate it, the operator can control the speed of rotation to optimize the welding process. This eliminates any variations in weld filler material deposition due to the operator, and provides for a more consistent and higher quality weld.

Welding Positioner Types

As stated above, there are many different types of welding positioners. Outlined below are examples of the basic types available from Harris Machine Tools and the Steady-Weld brand. Custom positioners may also be designed for very specific welding applications.

Table Tilt and Rotate Type Welding Positioners (Gear driven with powerful rotation and tilt motors. Table rotation for all types is 360 deg. Table tilt varies from 0 to 90 deg., 0 to 120 deg., 0 to 135 deg., and up to 360 deg. for drop center and double column types).

- Fixed Height
- Adjustable Height (manual, hydraulic and mechanical lifting mechanisms)
- Drop Center
- Double Column Lift (mechanical and hydraulic lifting mechanisms)

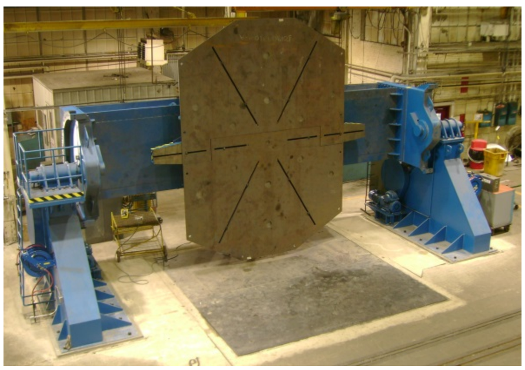
Table Rotate Only Welding Positioners (gear driven rotation motors)

- Head and Tailstock (horizontal axis rotation)
- Floor Table (vertical axis rotation)

Fixed Height

Adjustable Height

Floor Table



Drop Center

Head & Tailstock

Double Column

Selecting the Right Welding Positioner

In order to select the right welding positioner, it is important for the buyer or operator to know the sizes, weights and shapes of the work pieces that will be welded on the positioner. Generally, the largest size and heaviest piece will determine the minimum size positioner required.

The following sections show the basics of calculating the Center-of-Gravity (CG) for a work piece, and how this CG, along with the weight of the piece, will determine the size of positioner needed. In these examples, we will use a Tilt & Rotate, Fixed Height type positioner to illustrate the concepts of Gravity Center Distance, Eccentricity Distance, Tilting Torque, Rotational Torque, and Swing.

Calculating the Center-of-Gravity of a Work Piece

The Center-of-Gravity (CG) is generally near the geometric center of the work piece. In the case of a symmetrical work piece of consistent material density, it is exactly in the center. In the case of an asymmetrical work piece, the CG can be calculated based on the sizes, positions and weights of the symmetrical parts that make up the entire work piece.

To calculate the CG for any object, break the object down into symmetrical parts for calculating the moment for each part (moment means force, or tendency to produce motion, a moment is weight multiplied by distance). For each symmetrical part the CG will always be in the exact center of the part. In order to properly calculate the CG for the entire weldment, it is necessary to calculate the moment for each part in 3 dimensions, i.e. for the X, Y, and Z axes.

Below is an example of a main pipe with an extending outlet pipe and flange (Figure 1). For this example we have three separate symmetrical parts to deal with. The main pipe body is one part, the side pipe outlet is another, and the flange on the end of the outlet is the third.

To calculate the moment of each part we need to select a datum point as a reference. In this case, we will assume that the whole structure has been placed on the welding positioner table as shown in the diagram (Figure 2), therefore, the top center of the welding positioner table becomes the reference point for these calculations.

First, we need to calculate the weight of each component, and sum them for the weight of the entire weldment. In this example, we will assume the materials are steel and that the weight of the steel is 0.283 lbs./cu. in.

To calculate the weight of the cylindrical pieces, we need to know the circumference of the cylinder. The circumference is Pi (3.14) times the diameter of the cylinder.

To determine the total cubic inch volume of the pipe material, we multiply the wall thickness by the length by the circumference. Please note that in actuality, the main body pipe would have a section of it cut out where the outlet pipe is welded to it. The small volume of material removed will have an effect (albeit negligible) on the CG for the main body pipe. In this example we will ignore this effect for simplicity.

After calculating the weight of the individual pieces, we can determine the moment for each piece, and the CG for the entire weldment. With this information, we are able to determine the Gravity Center Distance, Eccentricity Distance, Rotational Torque requirement, and Tilting Torque requirement.

There is one other dimension that needs to be considered, the swing of the positioner. The swing is the maximum diameter that can be turned when the table is fully tilted to the vertical position (90 deg.). The distance from the center of the table to the floor, or in some cases the positioner support legs, when the table is positioned vertically, is half the value of the swing diameter. This dimension is usually given in the technical specifications section of the Operation Manual and is almost always designated on the technical drawings. It is important to know this to make sure that the work piece will rotate without hitting the floor, or any other obstruction, when the table is fully tilted.

Example: Main pipe body with outlet and flange

In this example there are three symmetrical parts that make up the entire weldment (a, b, and c)

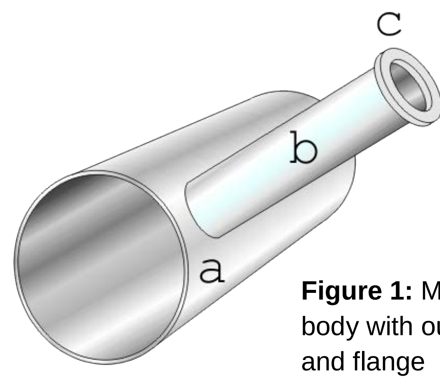
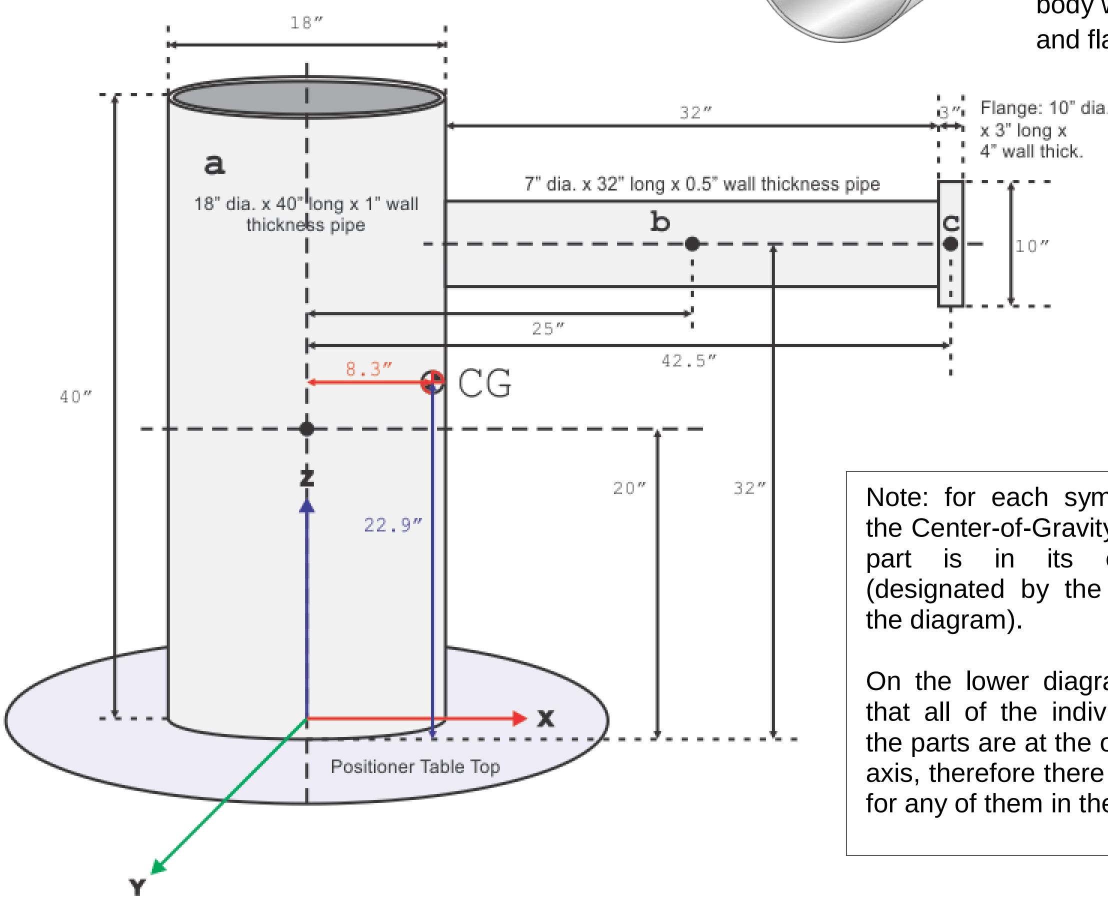


Figure 1: Main pipe body with outlet pipe and flange



Note: for each symmetrical part, the Center-of-Gravity (CG) for that part is in its exact center (designated by the solid dots in the diagram).

On the lower diagram, also note that all of the individual CGs for the parts are at the origin for the Y axis, therefore there is no moment for any of them in the Y plane.

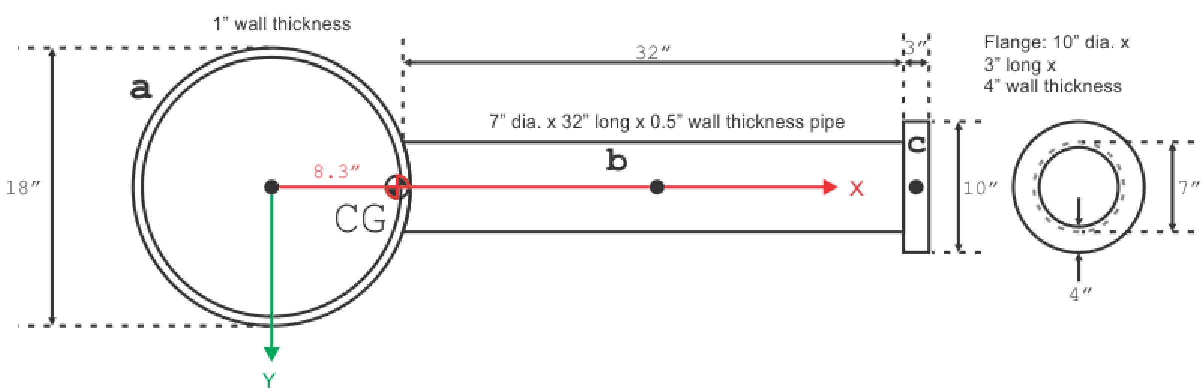


Figure 2: Dimensions and values needed to determine CG for the entire part

Weight Calculations

Calculate the weight of each part (assume all material is steel that weighs 0.283 lbs./cu. in.). Circumference of a cylinder is Pi (3.14) times diameter. Volume of material in a pipe is wall thickness times length times circumference.

Main pipe (a): 1 x 40 x (3.14 x 18) = 2260.8 cu. in.

2260.8 cu. in. x 0.283 lbs./cu. in. = **639.8 lbs.**

Outlet pipe (b): 0.5 x 32 x (3.14 x 7) = 351.7 cu. in.

351.7 cu. in. x 0.283 lbs./cu. in. = **99.5 lbs.**

Flange (c): 4 x 3 x (3.14 x 10) = 376.8 cu. in.

376.8 cu. in. x 0.283 lbs./cu. in. = **106.6 lbs.**

Total weight: 845.9 lbs.

Center-of-Gravity Calculations

Calculate the moment of each part in each dimension (X, Y, and Z) and the CG for each dimension.

Mx = Ma + Mb + Mc = 0 + 25(99.5) + 42.5(106.6) = 7018 in-lbs

CGx = 7018 / 845.9 = 8.3 in.

My = Ma + Mb + Mc = 0 + 0 + 0 = 0 in-lbs (see note in Example diagram for explanation for no moment in the Y plane)

CGy = 0 / 845.9 = 0 in.

Mz = Ma + Mb + Mc = 20(639.8) + 32(99.5) + 32(106.6) = 19391.2 in-lbs

CGz = 19391.2 / 845.9 = 22.9 in.

The CG for the entire weldment is 22.9” above the positioner table in the Z axis, and 8.3” offset from the center of the table along the X axis. There is no offset along the Y axis.

Gravity Center Distance and Eccentricity Distance

The calculations above that give us the CG for the entire weldment also tell us the Gravity Center distance and the Eccentricity distance for that work piece. These are important to know in order to select a positioner that is capable of handling the weight of the piece and its Center-of-Gravity for rotating and tilting.

In actuality, we should also include the weights and CGs for all of the clamps and fixtures used to hold the work piece to the table in our calculations, but we will omit them for simplicity in this exercise.

The diagram in Figure 3 shows the maximum load rating for the positioner, the maximum rotational and tilting torques, the maximum Gravity Center and Eccentricity distances, and the load capacities for various Gravity Center and Eccentricity distances. It also shows the Inherent Overhang for the positioner.

In the example above, the weight of our work piece is 845.9 lbs., the Gravity Center distance is 22.9” above the table surface, and the Eccentricity distance is 8.3” offset from the table center.

Rotational Torque and Tilting Torque

Knowing the Gravity Center distance and the Eccentricity distance, we can calculate the rotational torque and tilting torque required to position the work piece.

Rotational Torque = Weight of work piece (lbs.) x eccentricity distance (in.)

Tilting Torque = Weight of work piece (lbs.) x (gravity center distance (in.) + inherent overhang (in.))

Inherent overhang is the distance from the tilting pivot point of the table to the surface of the table. This value is also included in the charts or diagrams for each positioner (Fig. 3).

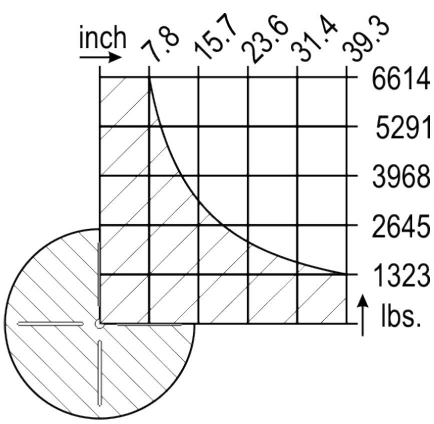
In our example from above:

Rotational Torque required is: 845.9 lbs. x 8.3 in. = 7021 lb-in

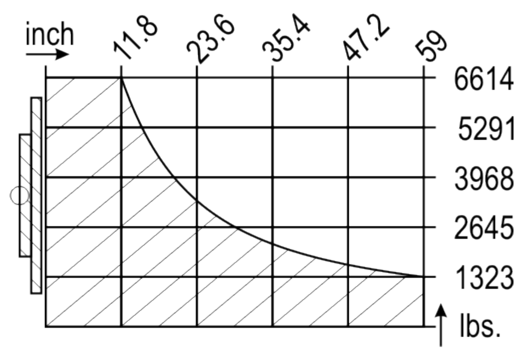
Tilting Torque required is: 845.9 lbs. x (22.9 in. + 7.87 in.) = 26028 lb-in

We can also calculate the maximum rotational and tilting torque of any positioner, knowing the maximum table load capacity, the inherent overhang, the maximum eccentricity distance, and the maximum gravity center distance. These values are supplied in the Technical Specifications section of most Operation Manuals.

Charts for the Eccentricity distance and Gravity Center distance are generally also supplied. Below is an example of the charts for a 3 ton fixed height positioner. The Inherent Overhang for this model is 6.875”.



Eccentricity Distance Chart



Gravity Center Distance Chart

Calculating Maximum Rotational and Tilting Torque for a Positioner

Max. Rotational Torque = Max load cap. (lbs.) x eccentricity distance (in.) = 6614 lbs. x 7.8 in = 51589 lb-in of rotational torque

Max. Tilting Torque = Max. load cap. (lbs.) x (gravity center distance (in.) + inherent overhang (in.)) = 6614 lbs. x (11.8 + 6.875) = 123516 lb-in of tilting torque

Table 1 shows a comparison of various parameters for a series of fixed height welding positioners with tilting and rotating tables. From this table, we can pick a positioner that meets all of our requirements, i.e. work piece weight (845.9 lbs.), rotational torque required (7021 lb-in) and tilting torque required (26028 lb-in).

We can see that the P1.2-F (1.2 ton or 1200 kg capacity) positioner meets all of our requirements. It is capable of handling a maximum load of 2640 lbs., with 20777 lb-in of rotational torque and 43138 lb-in of tilting torque. Note that the one size smaller positioner (P06-F) is capable of handling the weight and the rotational torque, but not the tilting torque. It is always better to purchase a positioner with a greater weight handling capability and maximum torques than one that would be borderline for handling the largest and heaviest of your anticipated work pieces. Safety in handling and positioning the work piece should be the foremost consideration.

The diagram on the next page (Fig. 3), is a visual representation of the maximum work piece weights that the P1.2-F positioner can handle based on the Gravity Center and Eccentricity distances for the positioner. From this we can see that for the eccentricity distance of our work piece (8.3") and the gravity center distance (22.9"), the positioner will easily handle the weight of our work piece (845.9 lbs.)

These exercises should show how important it is to know how to calculate the parameters of your work piece (weight, work piece Center-of-Gravity, Gravity Center distance, Eccentricity distance, and torque requirements) in order to select the proper positioner that will provide you with years of safe and reliable service.

Model	Table Dia. (in)	Max. Load (lbs)	Max. Gravity Center Dist. (in)	Max. Eccentricity (in)	Inherent Overhang (in)	Max. Tilting Torque (lb-in)	Max. Rotational Torque (lb-in)
P03-F	22	660	7.87	5.91	5.71	8963	3900
P06-F	27.5	1320	9.84	5.91	5.71	20526	7800
P1.2-F	39.3	2640	11.81	7.87	5.11	44669	20777
P2-F	43.3	4400	11.81	7.87	6.89	82280	34628
P3-F	51.2	6600	15.75	7.87	7.09	150744	51942
P5-F	59	11,000	11.81	7.87	7.68	214390	86570
P10-F	78.7	22,000	15.75	7.87	9.06	545820	173140
P15-F	86.6	33,000	19.68	7.87	16.14	1182060	259710
P20-F	98.4	44,000	25	7.87	17.72	1879680	346280

Table 1: Specifications table for fixed height, table tilt and rotate type welding positioners. For example use only.

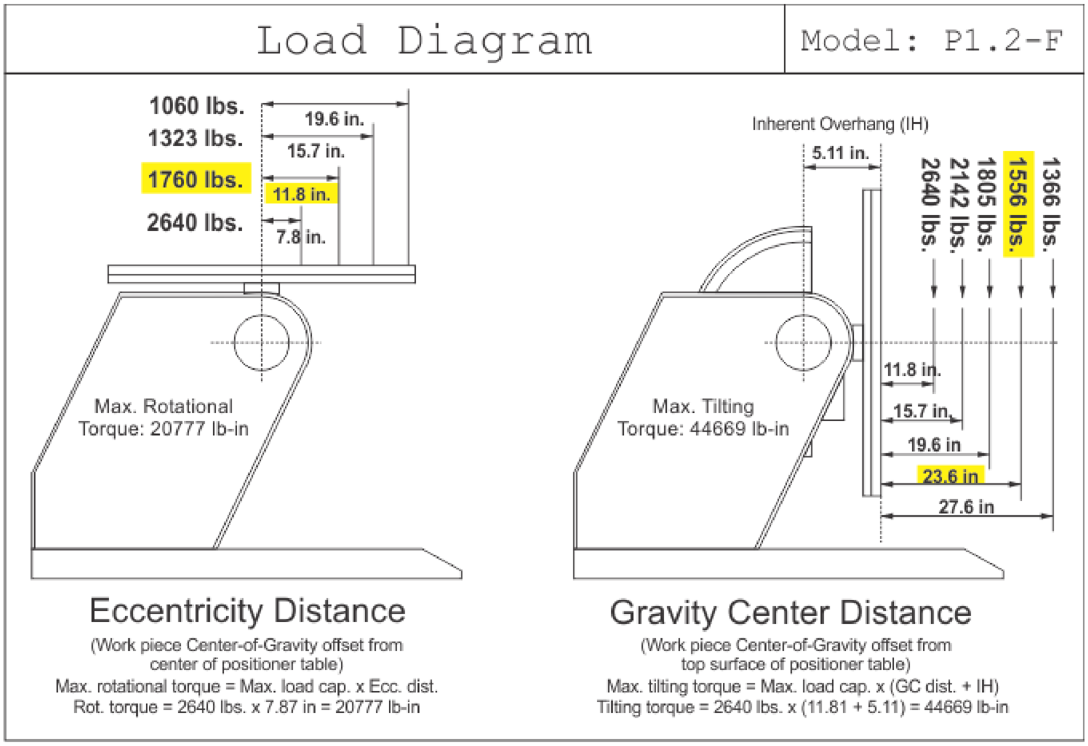
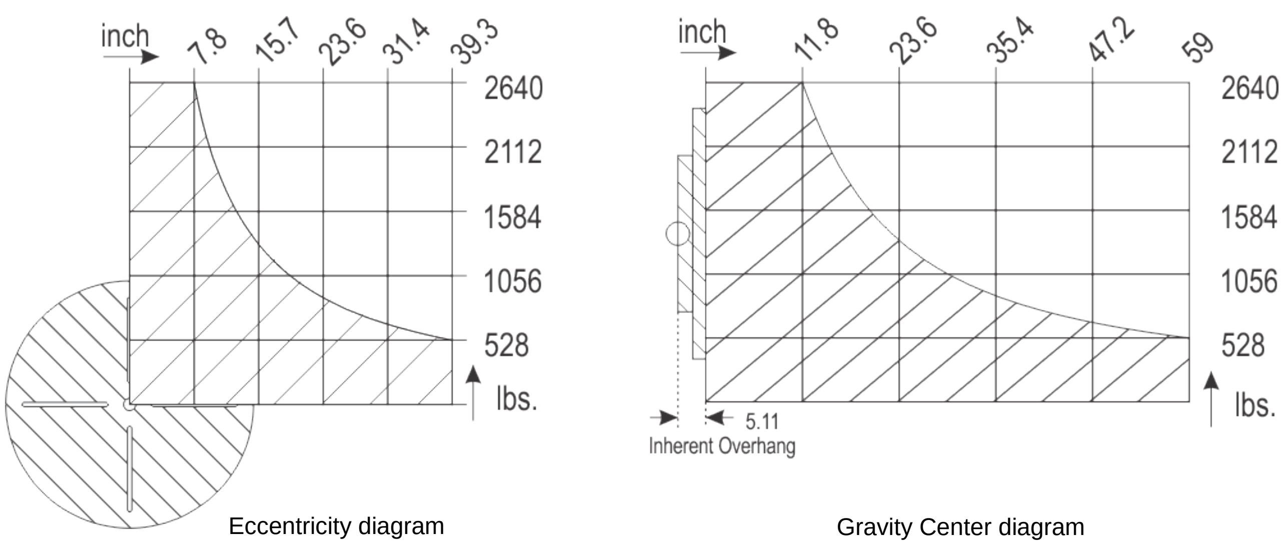


Figure 3: Torque diagram for positioner rated for maximum 2640 lb. load; showing maximum rotational and tilting torques, as well as weight capacities for various Gravity Center and Eccentricity distances.



Eccentricity diagram

Gravity Center diagram

Figure 4: Eccentricity and Gravity Center diagrams for P1.2-F positioner.

Positioner Table Swing

We have calculated the weight of our work piece, its Center-of-Gravity, the Gravity Center distance, the Eccentricity distance, and the Rotational and Tilting Torque requirements. Another parameter we need to consider is the size of our work piece, and whether or not we will be able to rotate it 360 degrees in the horizontal plane.

Figure 4 shows the work piece in relation to the positioner table when the table is tilted to 90 degrees and the part is mounted on the table as shown in our example above. As we can see, this positioner is not tall enough to accommodate our part in this position.

If the part does not need to be turned in the horizontal plane, all other aspects of this positioner will work for us. If the part does need to be turned in the horizontal plane, we would need to either look for a positioner that has the same load ratings as this one, but is either taller or has an adjustable height feature. Another option would be to mount this positioner on a raised base to achieve the extra height needed.

The part could also be mounted in a different position such that it will rotate the full 360 degrees (see Fig. 4a).

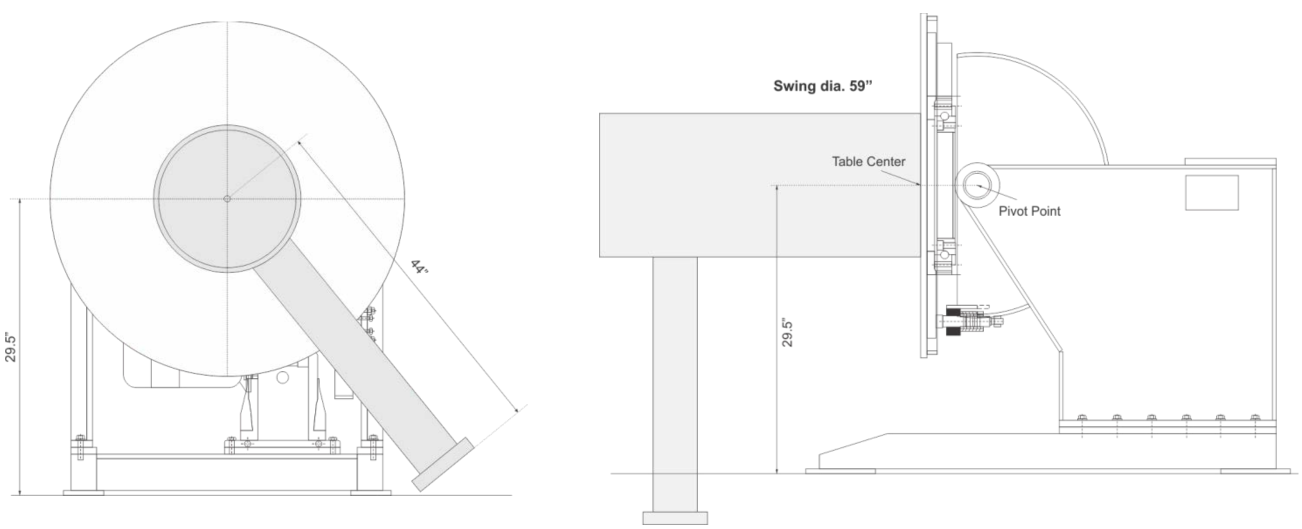


Figure 4: Example of the swing of a positioner when the table is fully tilted (90 deg.).

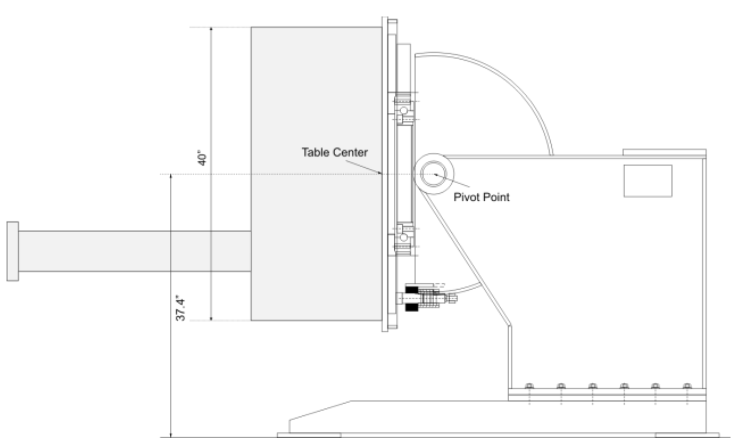


Figure 4a: Alternate mounting example of the work piece to utilize the full swing of the positioner when the table is tilted to 90 deg.

Calculating Welding Speed

The positioner cannot only tilt the work piece, but can rotate it at a constant speed within its rated speed range. The positioners are gear driven with powerful rotation and tilt motors with self locking worm gear reducers and electro-mechanical brake motors that lock when the power is shut off. Rotation power is supplied by an AC inverter drive and powerful rotation motor.

Speed control is infinitely variable between the minimum and maximum speeds (generally between 0.1 to 1 rpm for smaller models, and 0.05 to 0.5 rpm for larger models). The design of the positioner gear drives and motors allows for a constant rotational speed, even with an unbalanced or eccentric load in a tilted position.

If a desired welding speed is needed for a particular application (especially for cylindrical pieces), it is easy to calculate the speed at which to turn the work piece to achieve it. There is a simple formula to calculate the relationship between surface speed of the weld (Ws, in inches per minute), the speed of the positioner (Ps, in revolutions per minute), and the distance (circumference) to be welded (Dc, circumference of the cylindrical work piece). This formula is:

$$Ws=Ps \times Dc$$

If you know the desired surface speed for welding (Ws), and the circumference of the work piece (Dc), you can solve for Ps, the desired speed at which to set the positioner. Conversely, you can solve for any variable if the other two are known. Generally, the desired welding speed and the size (circumference) of the work piece are the two known variables. The desired welding speed usually depends on the materials being welded and the rate of deposition for the filler material, and the size (circumference) of the work piece is also known because it can be directly measured or easily calculated.

An easy way to calculate the remaining variable, when two are known, is by the following diagram. By removing the variable you wish to find, and performing the mathematical function shown with the other two, you can calculate the variable you need. For example, to find the speed at which to rotate the positioner for a desired welding speed, remove the Ps (the value we wish to find) from the equation, and perform the remaining calculation: Ws divided by Dc.

If we wish to know the maximum welding speed we can achieve with this positioner, remove the Ws and multiply the maximum Ps (max. rated rpm of the positioner) times the maximum distance (circumference) of the work piece. This will give us the maximum welding speed we can achieve.

Ws
Ps x Dc

Calculating Welding Speed

For example, if we are welding the flange onto the end of the extension pipe in our example above, we would need to mount the work piece to the table in such a way that the longitudinal axis of the extension pipe is centered over the center of the table, and the table is tilted 90 degrees (Fig. 5). This will allow the pipe and flange to turn about their axes and allow the welder to weld the seam in a downhand position.

To calculate the speed at which we need to rotate the work piece, we need to know two of the three variables. The circumference of the extension pipe is known (3.14 x 7 = 22 in.).

The welding surface speed is selected based on the materials being welded, the welding method, and the filler material being used. For this example we will assume that the optimum welding speed is 6 ipm (inches per minute).

So to solve for Ps we get:

Ps = Ws / Dc = 6 ipm / 22 in. = 0.27 rpm

Therefore, we need to set the positioner speed to 0.27 rpm for this welding operation. The speed can be set from the hand held control pendant using a speed potentiometer dial and a digital speed readout, if the positioner is equipped with one. If a digital readout is not available, the speed can be calculated by measuring the time it takes to make one revolution and then adjusting the speed to the desired rpm rate.

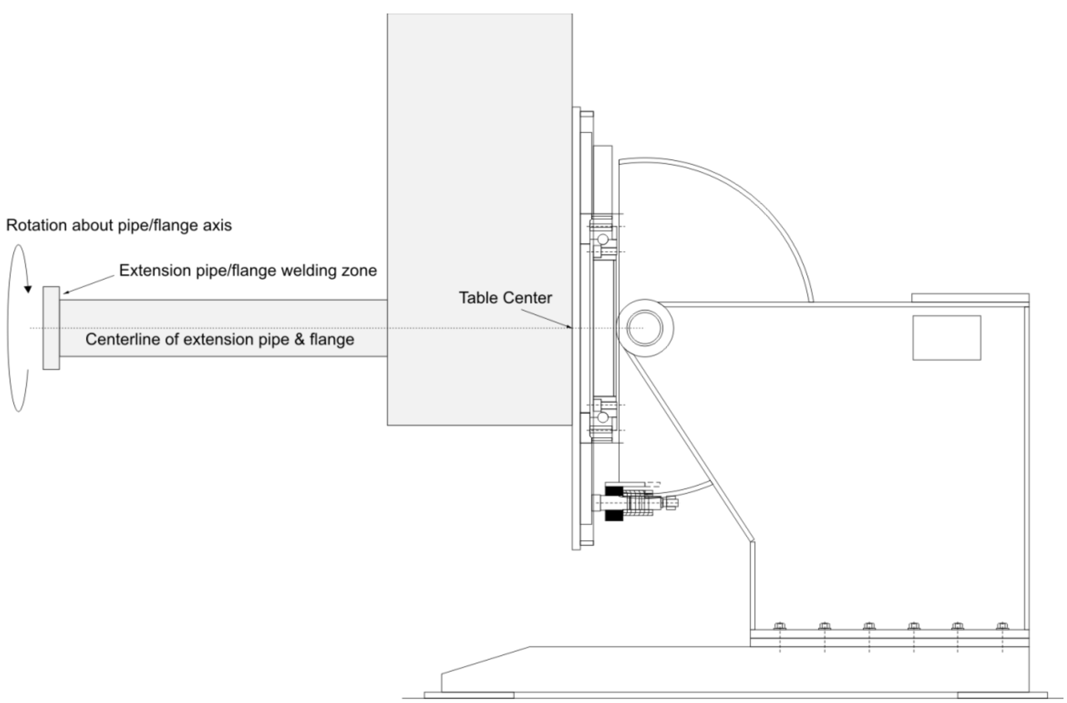


Figure 5: Mounting the work piece for welding the pipe and flange