

The Practical Reference Guide to Positioning

This publication is designed to provide information in regard to the subject matter covered. It is made available with the understanding that the publisher is not engaged in the rendering of professional advice. Reliance upon the information contained in this document should not be undertaken without an independent verification of its application for a particular use. The publisher is not responsible for loss or damage resulting from use of this publication. This document is not a consensus standard. Users should refer to the applicable standards for their particular application.



American Welding Society

550 N.W. LeJeune Road, Miami, FL 33126



Documents

Document Sharing Hub

Acknowledgments

Information and excerpts throughout this Guide have been adopted from The New Handbook of Positioneering, courtesy of Koike Aronson, Inc., Arcade, NY., and additional input provided by Pandjiris, Inc. Photographs are courtesy of Pandjiris, Inc., St. Louis, MO.

International Standard Book Number: 978-0-87171-086-4
American Welding Society
550 N.W. LeJeune Road, Miami, FL 33126
© 2008 by American Welding Society
All rights reserved
Printed in the United States of America

Photocopy Rights. No portion of this document may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner.

Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <www.copyright.com>.

Basic Safety Precautions

Burn Protection. Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause burns if precautionary measures are not used. Workers should wear protective clothing made of fire-resistant material. Pant cuffs, open pockets, or other places on clothing that can catch and retain molten metal or sparks should not be worn. High-top shoes or leather leggings and fire resistant gloves should be worn. Pant legs should be worn over the outside of high-top shoes. Helmets or hand shields that provide protection for the face, neck, and ears, and a head covering to protect the head should be used. In addition, appropriate eye protection should be used.

Electrical Hazards. Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. The manufacturer's instructions and recommended safe practices should be read and understood. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger. All electrical equipment and the workpiece should be grounded. The workpiece lead is not a ground lead. It is used only to complete the welding circuit. A separate connection is required to ground the workpiece. The workpiece should not be mistaken for a ground connection.

Fumes and Gases. Many welding, cutting, and allied processes produce fumes and gases which may be harmful to health. Avoid breathing the air in the fume plume directly above the arc. Do not weld in a confined area without a ventilation system. Use point-of-welding fume removal when welding galvanized steel, zinc, lead, cadmium, chromium, manganese, brass, or bronze. Do not weld on piping or containers that have held hazardous materials unless the containers have been properly made inert.

Compressed Gas Cylinders. Keep caps on cylinders when not in use. Make sure that gas cylinders are chained to a wall or other structural support. Do not weld on cylinders.

Radiation. Arc welding may produce ultraviolet, infrared, or light radiation. Always wear protective clothing and eye protection to protect the skin and eyes from radiation. Shield others from light radiation from your welding operation.

Special Precautions. In the following conditions when welding aluminum alloys: (1) High levels of fumes are produced when using the 5XXX (magnesium-bearing) aluminum filler metals. (2) The use of argon-based shielding gas blends results in the production of ozone, especially with 4XXX filler metals. The use of filtering masks or airline respirators will be required if it is determined that personnel are being exposed to excessive pollutants. Caution must also be observed in the reaction between aluminum and certain solvents and cleaners. Consult information provided by manufacturers for the necessary safe practices in the use of their products. AWS also recommends a personal copy of "Arc Welding Safely", "Fire Safety in Welding and Cutting", and "Safety in Welding, Cutting, and Allied Processes".

AWS publications may be purchased from the American Welding Society at <http://www.aws.org> or by contacting the AWS at 800-854-7149.

Intentionally Left Blank

TABLE OF CONTENTS

	Page No
Practical Reference Guide to Positioning	1
Acknowledgments	2
Basic Safety Precautions	3
I. Introduction	9
II. Weldment Positioning Equipment	9
A. Positioner Basics	10
1. Determining the Center of Gravity	10
2. Finding the Center of Gravity Experimentally	12
3. Mounting Work onto a Weldment Positioner	14
4. Welding Chucks	17
5. Work Lead Connections	19
6. Floor Anchors	20
B. Tilting-Rotating Positioners	21
1. Selecting Positioner Capacity	22
2. Tilt Torque	23
3. Rotation Torque	26
4. Swing Clearance	27
5. Constant and Variable Speed Positioners	27
6. Calculating Surface Speed	27
7. Speed Regulation	28
C. Powered-Elevation Positioners	29
D. Drop-Center Tilting Positioners	30
E. Turntable Positioners	31
1. Turntable Capacity Ratings	32
F. Headstock and Tailstock Positioners	33
1. Large Workpiece Inertia	34
2. Mounting Workpieces on Headstock and Tailstock Positioners	35
3. Determining Swing Clearance	38
4. Powered-Elevation Headstock and Tailstock Positioners	39
G. Balancing Positioners	39
1. Determining Load Capacity	39
2. Mounting the Work on Balancing Positioners	41
3. Making Minor Balance Adjustments	41
4. Motorized Tables	42
III. Turning Rolls	42
A. Fixed Centerline Turning Rolls	43
B. Adjustable Centerline Turning Rolls	43

	Page No
C. Fit-Up Rolls	44
D. Unitized-Frame Turning Rolls	45
E. Tilting Turning Rolls	46
F. Sling Style Rolls	46
G. Powered and Idler Rail Cars	46
H. Non-Cylindrical Work	47
I. Pipe Hold-Down Attachments	47
J. Weight Capacity	48
K. Rotation Power Ratings	48
L. Tractive-Pull Ratings	48
M. Included Angle	50
N. Traction Calculation	51
O. Selection of Turning Roll Wheel Materials	53
P. Alignment	53
Q. Overturning Instability	55
R. Setting Up Turning Rolls for Multiple Sections	57
S. Shock Loading	59
T. Weld Joints	59
IV. Welding Head Manipulators	59
A. Manipulator Selection	60
B. Lift	62
C. Lift System Safety	64
D. Reach	64
E. Mast Rotation	64
F. Car Travel	65
G. Powered Motions	65
H. Manipulator Load Capacity	65
I. Location and Mounting of Welding Head Manipulators	66
J. Manipulator Equipment and Accessories	66
V. Side Beam and Carriage Equipment	67
A. Side Beam and Carriage Equipment and Accessories	67

	Page No
VI. Safety Considerations.....	69
A. Environmental Interference	69
B. Fastening Loads	70
C. Avoiding Instability	70
D. Other Safe Practices	70
E. Economic Considerations	71
F. Deposition Rates	71
G. Operator Factor and Set-Up Costs	71
H. Welding Skill	71
VII. Conclusion	72
VIII. Bibliography	72
IX. Safety Documents	73

List of Tables

Table	Page No.
1 Determining Traction for Selected Included Angles.....	53

List of Figures

Figure	Page No.
1 Center of Gravity of a Solid Cube	11
2 Center of Gravity of a Cylindrical Object.....	11
3 Finding the Center of Gravity of Small Workpieces	13
4A Finding the Center of Gravity of Large Workpieces by Balancing them on a Pipe	13
4B Alternate View.....	13
5A Finding the Center of Gravity and Weight of a Workpiece using a Hoist and Scale .	14
5B Alternate View.....	14
6 Effects of Tilting and Weldment Geometry on Positioner Fastener Requirements ...	16
7 Use of a Three-Jaw Self-Centering Chuck.....	18
8 Calculation of Total Tilt-Load Moment Requirements	19
9 Force of Inertia on the Base of a Positioner	20
10 Typical 135° Tilting-Rotating Positioner with the Table in the Flat Position	21
11 Examples of 45° - 90° and 135° Tilting-Rotating Positioner.....	22
12 Typical Tilting-Rotating Positioner	24
13 Workpiece Mounted on Tilting-Rotating Positioner	24
14 Capacity Plate Data for a Tilting-Rotating Positioner.....	25
15 Rotation Axis of the Positioner as the Fulcrum	27
16 Diagram for Determining Revolutions Per Minute.....	28
17 Powered-Elevation Positioner in the 135° Tilt-Down Position.....	29

Figure		Page No.
18	Positioning Three Different Welds on a Spool-Shaped Workpiece Using an Elevating Positioner	30
19	Drop-Center Tilting Positioner	31
20	Typical Turntable Positioner	32
21	Turntable Capacity Ratings	33
22	Typical Headstock and Tailstock Positioners	35
23	Headstock and Tailstock Positioner Ratings for Overhanging Load Capacity.....	35
24	Effect of Rotational Inertia of Large Workpieces	36
25	Misalignment of Headstock and Tailstock Due to Rigid Mounting of Workpiece	38
26	Pilot Mounting Method Overcomes Minor Misalignment	38
27	Universal-Pin Mounting System	38
28	HTS Positioners with Powered Elevation Feature.....	39
29	Intersection of Tilt and Rotation Axes on Balancing Positioner	40
30	Determining Load Capacity of a Balancing Positioner	40
31	Installation of a Counterweight	42
32	Fixed Centerline Turning Rolls	43
33	Adjustable Centerline Turning Rolls	44
34	Vessel Turning Rolls with Adjustable Centerline.....	44
35	Using Turning Rolls for Fit-Up Roll Adjustment.....	45
36	Unitized-Frame Turning Rolls	45
37	Rail Cars for Powered and Idler Turning Rolls	47
38	Turning Roll Setup for Non-Cylindrical Work	47
39	Tractive-Pull Ratings	49
40	Comparison of Included Angle of Workpieces.....	50
41	Calculating Included Angle for Turning Rolls	52
42	Proper Setup for Turning Roll Alignment	54
43	Conditions that Cause End-Creep	55
44	Intentional Misalignment of Turning Rolls to Counteract End-Creep	55
45	Overturning Instability of Workpiece on Turning Rolls	56
46	Turning Roll Set Up for Workpiece with Multiple Sections	58
47	Welding Head Manipulator and Multiple Turning Roll Alignment System.....	58
48	Bent Workpiece Supported by Multiple Turning Roll Units	58
49	Basic Motions of a Welding Head Manipulator	60
50	Large Model Welding Head Manipulator	61
51	Welding Head Manipulator with Welding Equipment Installed on Both Ends of the Boom	61
52	Determining Extreme arc Positions for Reach and Lift.....	61
53	Determining Overall Height of a Vessel on Turning Rolls.....	63
54	Lift Range of a Welding-Head Manipulator	63
55	Determining Horizontal Boom Travel.....	64
56	Basic Side Beam and Carriage Application.....	68
57	Welding Lathe.....	68
58	Side Beam and Carriage Application	69

I. INTRODUCTION

This Practical Reference Guide describes the basic operation of weldment positioners and welding head manipulators and gives information on their selection and use. Weldment positioners hold and move a workpiece into the desired positions for welding and other related operations. Welding head manipulators hold and move the welding head and welding torch as the weld is made. Positioners and welding head manipulators can be used individually and in combination with each other or with other equipment for manual, semi-automatic, mechanized, automated, or robotic welding operations. Weldment positioners and welding head manipulators are particularly useful to reduce operator fatigue, increase welding speed, and reduce production time for long weld joints, circumferential joints, and thick joints that require multiple weld passes. They can help improve productivity, reduce costs, and improve weld quality.

CAUTION: THIS DOCUMENT INCLUDES GUIDELINES FOR THE OPERATION, SELECTION AND USE OF WELDMENT POSITIONERS AND WELDING HEAD MANIPULATORS. CALCULATIONS OF LOADS AND FORCES ON EQUIPMENT AND DESIGN OF MOUNTING METHODS FOR EQUIPMENT, TOOLING, AND WORKPIECES ALWAYS SHOULD BE DONE BY A QUALIFIED ENGINEER OR BY THE MANUFACTURER OF THE EQUIPMENT.

II. WELDMENT POSITIONING EQUIPMENT

Positioners are mechanical devices that support and move a workpiece to the desired position for welding and other related operations. Positioning equipment is available in a number of configurations, depending on the motions required to properly position the work. Weldment positioning equipment includes the following types:

- ☐ Balancing positioners that are designed to permit manual movement of the workpiece. (See section: II.G.)
- ☐ Tilting-rotating positioners provide two powered axes of motion. (See section: II.B.)
- ☐ Powered elevation positioners add powered vertical motion to tilting and rotation motions of the table. (See section: II.C.)
- ☐ Drop-center tilting positioners are specially designed so that the surface of the table is along or below the tilt axis. (See section: II.D.)
- ☐ Turntable positioners have tables that rotate about a vertical axis but do not tilt. (See section: II.E.)
- ☐ Headstock and tailstock positioners provide motion to rotate a workpiece about a horizontal axis and do not tilt. (See section: II.F.)
- ☐ Turning rolls hold and turn cylindrical parts about their horizontal axis. (See section: III.)

Selection of the proper type of positioning device depends on factors that are described in the following sections of this document. These factors include the size, weight, and complexity of the workpiece as well as the number, location, and orientation of the weld joints. One of the first decisions to be made is how many axes of motion will be needed to properly position the weldment. Turning rolls, turntable positioners, and headstock and tailstock positioners provide motion about only one axis. Tilting-rotating positioners provide two axes of motion. Three motion axes are achieved by adding vertical motion to a tilting-rotating positioner, by combining more than one of the basic motion devices, or by the use of fixtures and tooling.

This Practical Reference Guide also describes welding head manipulators. While welding positioners can be used to move the workpiece, welding head manipulators move the welding process equipment to or over the work. Two types of welding head manipulators are included in this document:

- Welding head manipulators consist of a vertical mast and horizontal boom to which the welding head is mounted. The manipulator provides two, three, four, or more axes of motion and can be mounted in a fixed position or on a traveling car.
- Welding side beams and carriages position the welding head in two axes and provide a single axis of motion, usually straight-line motion.

A. Positioner Basics

The first decision to make when selecting a welding positioner is to determine the number of axes of motion that are required to position the weld joints on the parts to be welded. The next decision involves selecting the proper size and load rating of the positioning equipment. Manufacturer's size and capacity ratings of positioners are based on the weight and the location of the center of gravity of the load the positioner is designed to carry. The load includes the weldment and any tooling or fixtures that also will be mounted on the positioner. Working within the manufacturer's capacity rating ensures that the positioner can not only safely support the load, but that the motion axes are designed with the proper torque to move the load.

(1) Determining the Center of Gravity

Knowing how to locate the center of gravity of the workpiece and associated fixtures is necessary in order to calculate the loads and torque requirements when selecting a positioner. The location of the center of gravity (CG) or center of balance is important because the entire weight of a body can be assumed to be concentrated at this location when making engineering calculations. The center of gravity of a weldment, fixture, or other component can be obtained from engineering drawings or calculated by qualified personnel. If necessary, the center of gravity can be determined experimentally using the methods described in this document.

The center of gravity of any object is located somewhere within its dimensions. The center of gravity of a symmetrical object with uniform density is at the geometric center of the object or on an axis of symmetry.

The solid cube in Figure 1 is one example. The center of gravity is at the center of the cube and is midway between each of the faces. The center of gravity of a hollow cube also is midway between the faces, as long as each face weighs the same. A cylindrical object, such as that shown in Figure 2 has a center of gravity located at the geometrical center of the cylinder. The center of gravity would not be at the geometrical center of the cylinder if the cylinder had a dome-shaped head on one end or a structure extending from a side.

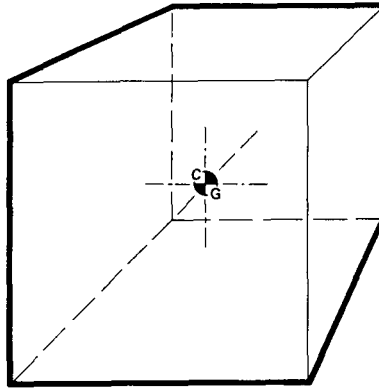


Figure 1—Center of Gravity of a Solid Cube

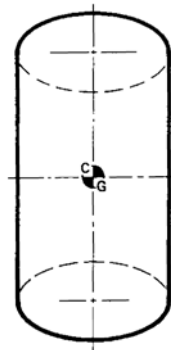


Figure 2—Center of Gravity of a Cylindrical Object

The center of gravity of complex objects can be determined by dividing the object into simple geometric shapes and calculating the center of gravity of each of these shapes using formulas from handbooks, engineering textbooks, or advanced 3-D modeling and engineering software. The center of gravity of the complex object can then be determined by transferring the center of gravity of each individual component as follows:

$$y = \frac{Aa_1 + Bb_1 + Cc_1}{A + B + C}$$

Where

y = the distance from the x axis to the common center of gravity in in. (m)

A = the weight of shape A in lb (N)

a_1 = the distance from the x axis to the center of gravity of shape A in in. (m)

B = the weight of shape B in lb (N)

b_1 = the distance from the x axis to the center of gravity of shape B in in. (m)

C = the weight of shape C in lb (N)

c_1 = the distance from the x axis to the center of gravity of shape C in in. (m)

Additional calculations are made to determine the location of the common center of gravity from both the Y and Z axes in the manner outlined above.

CAUTION: DETERMINING THE WEIGHT AND LOCATION OF THE CENTER OF GRAVITY OF WELDMENTS, TOOLING, AND FIXTURES SHOULD BE DONE BY A QUALIFIED ENGINEER OR OTHER QUALIFIED PERSONNEL.

(2) Finding the Center of Gravity Experimentally

The center of gravity of a workpiece can be located experimentally as well as by calculation. The center of gravity of small workpieces can be found by balancing them (including fixtures and attachments) on a round rod (or pipe) as shown in Figure 3.

The center of gravity of larger workpieces can be found by balancing them (including fixtures and attachments) on a round rod (or pipe) as shown in Figure 4A. Draw a vertical line on the part directly above the rod. Repeat this procedure by rotating the workpiece 90 degrees and balancing it on an adjacent side as shown in Figure 4B. Draw another line vertically from the rod as shown in the figure. Repeating the procedure after rotating the part another 90 degrees results in lines on each of the three primary axes of the part. The intersection of these three lines marks the center of gravity of the part.

Another method that can be used to find the center of gravity of large workpieces uses a crane or hoist. Suspend the workpiece from a hoist or crane as shown in Figure 5A. A plumb bob from the hook of the hoist defines a line that passes through the center of gravity. Mark this line on the workpiece. Next, suspend the part from a second point and then a third point and repeat the plumb bob and marking steps. A scale can be used to measure the weight of the workpiece during one of the lifts. The center of gravity is located at the intersection of the three lines. The lines in Figure 5 show the results of both the balancing rod and hoist methods. Note that they indicate the same center of gravity location for the workpiece.

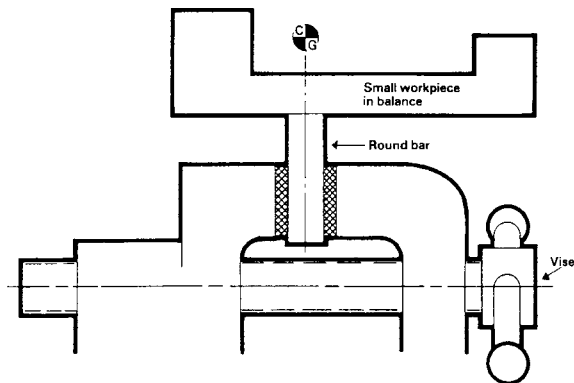


Figure 3—Finding the Center of Gravity of Small Workpieces



Figure 4A—Finding the Center of Gravity of Large Workpieces by Balancing them on a Pipe



Figure 4B—Alternate View



Figure 5A—Finding the Center of Gravity and Weight of a Workpiece using a Hoist and Scale



Figure 5B—Alternate View

(3) Mounting Work onto a Weldment Positioner

Positioners are equipped with round or square work-tables that may have radial slots for attaching parts or tooling. These work-tables also have pilot holes at their centers that will accept dowels, spindles, or centering bosses. A boss that is engaged in the pilot hole provides an easy method of centering fixture plates and provides a “shear-stop” that prevents the fixture from moving laterally on the table.

Two considerations must constantly be kept in mind when mounting heavy work on a welding positioner. First, the work must be firmly attached to the table so that it is secure as the table tilts and rotates. Second, shear stops must be provided to prevent the workpiece from sliding on the face of the table. Steel blocks tack welded to the table work very well as shear stops. Another method is to use a boss engaged in the pilot hole of the table, as described above.

If four bolts are tightened into four of the radial slots on the table, often both rules for safe mounting work (strong hold down and shear stops) are satisfied. If only two bolts are adequate, it is strongly recommend that shear stops also be added to the table surface around the work to prevent any possibility of the work sliding on the table. Pre-engineered holes in the workpiece can be used to mount it to the positioner, saving production and setup time.

One simple method of mounting a workpiece to a positioner is to weld it directly to the table, assuming that this does not harm the work. Use tack welds sufficiently large to handle shear stresses when the workpiece is in the vertical tilted position. These tack welds can be ground off to remove the work from the positioner. Positioner tables are durable and designed to be welded to. If the table surface becomes scarred, simply fill the scars with weld metal and dress the areas flat with a grinder. An alternative is to cover the positioner table with a tooling plate and weld the work to this plate. The plate can be replaced when it becomes worn or damaged.

Care must be taken when fastening a workpiece directly to the positioner table to prevent deforming the flatness of the table. Shims may be required to support areas of the workpiece in order to preserve the flatness of the table.

Figure 6 illustrates the attachment of a weldment to a positioner table. When the positioner table is horizontal (Figure 6A), the only force tending to move the weldment would be centrifugal force due to rotation. However, the weldment can slide as the table tilts (Figure 6B) and attachments are required to prevent this movement. The force of gravity acting on the weldment, parallel to the table, increases as the tilt angle increases (Figure 6C) and becomes equal to the weight of the weldment at 90° tilt. Tilting the table more than 90° can cause the weldment to rotate about the lower fasteners if it is not restrained by the upper fasteners (Figure 6C and Figure 6D). The two upper fasteners (F_1 and F_2) will be under tensile load due to the weight and location of the center of gravity of the weldment. The moment about the lower fastener P is the product of the weight (W) and the horizontal distance between the center of gravity and the lower fasteners, (x). As the tilt angle increases, the horizontal distance increases. The weight moment is balanced by the moment of the tensile force on the upper fasteners. Assuming the weldments in Figure 6C and Figure 6D are of equal weight (W) but the weldment in Figure 6D is longer and narrower than the one in Figure 6C, the force, F , can be determined by the following equation:

$$F = Wx/y$$

In both cases, x_2 is greater than x_1 , and y_2 is less than y_1 . Therefore, F_2 is greater than F_1 . Accordingly the attachments for the weldment in Figure 6D must be stronger than for Figure 6C. All attachments should be checked to confirm they have sufficient strength to withstand both shear and tensile forces acting on them and a suitable safety factor added.

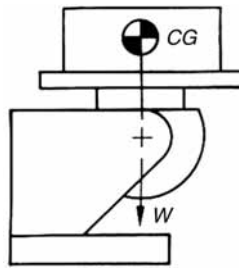


Figure 6A

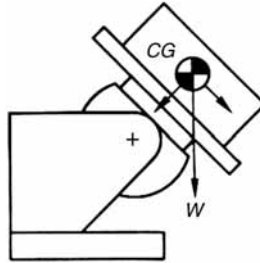


Figure 6B

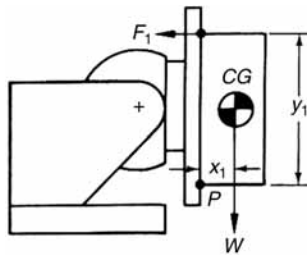


Figure 6C

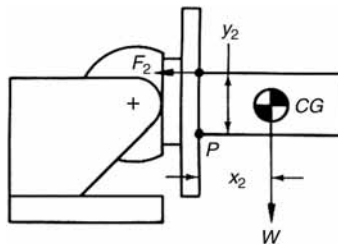


Figure 6D

KEY TO FIGURE

W = Weight of the load, lb (N)

F1, F2 = Tensile force on the upper fasteners, lb (N)

x_1 and x_2 = Horizontal distance between the table face and the center of gravity, in. (m)

P = Location of the lower fasteners

y_1 and y_2 = Vertical distance between the lower fasteners and the upper fasteners, in. (m)

Figure 6—Effects of Tilting and Weldment Geometry on Positioner Fastener Requirements (See Section II.A.3.)

CAUTION: MOUNTING METHODS, FASTENERS, AND TACK WELDING SHOULD BE DESIGNED BY A QUALIFIED ENGINEER OR DESIGNER WHO SHOULD ASSURE THAT THE MOUNTING IS ADEQUATE FOR THE LOAD AND THE APPLICATION. THE USER SHOULD ALWAYS FOLLOW ALL OF THE RECOMMENDATIONS OF THE MANUFACTURER OF THE EQUIPMENT.

(4) Welding Chucks

A welding chuck mounted onto a positioner table can provide a convenient method of clamping and centering a workpiece. However, characteristics of the workpiece and some basic rules for using chucks are critical to their safe use. The shape and structure of each workpiece imparts different loading characteristics on the chuck jaws. Also consider that the chuck can absorb heat, expand and lose its grip on a workpiece that is preheated.

The chuck jaws must clamp the workpiece on a rigid section to minimize the possibility of clamping failure. Clamping and centering should be performed on the largest diameter possible. Thin sections must be held with special jaws to overcome radial workpiece deflection while clamping. Surface finish of the workpiece and the chuck jaws play a major role in creating effective frictional forces needed for proper clamping. Several different types of chuck jaws are available for effective clamping of specific applications. As a rule of thumb, multiply the clamping force needed by two (X2) to help overcome misalignment, workpiece inaccuracies, and surface finish deficiencies.

Out of roundness of the workpiece can add a loading to each chuck jaw during rotation of the part. This cyclical loading, depending on the frequency and capacity, can create stresses that may cause jaw slippage or clamping failure. If one revolution is needed to finish the weld, a minor amount of slippage may be tolerated. When several rotations are required, the workpiece can slip enough to require periodic adjustment and re-clamping.

Overhanging and eccentric moments about the centerline of rotation must be reviewed to determine the adequacy of workpiece clamping when using a chuck. The moments created by an unsupported workpiece or centerline misalignment can overcome the clamping ability of the chuck and result in the workpiece becoming loose or coming out of the chuck.

A workpiece that is held in a chuck and is supported at another location can become loose in the chuck due to misalignment. Figure 7 shows a three-jaw self-centering chuck holding one end of a long workpiece. The length of the pipe in this example requires an outboard roller support to keep the pipe from overloading the chuck and levering itself out of the chuck jaws. Misalignment of the chuck and the rotation centerline of the positioner will tend to loosen the workpiece in the chuck jaws.



Figure 7—Use of a Three-Jaw Self-Centering Chuck

The chuck body adds weight and extends the distance to the center of gravity of the workpiece that it holds. The weight and center of gravity distance of the combined chuck and workpiece should be calculated to confirm that the positioner is suitable for the job. The example in Figure 8 identifies the moments due to the weight of the workpiece and chuck with the positioner in the 90° tilt position. Figure the moments of each item and add them together for a total moment requirement:

Chuck: 150 lb. X (6.8 in. + 4 in.) = 1,620 lb-in. (183 Nm)

Workpiece: 180 lb X (6.8 in. + 7 in. + 25 in.) = 6,980 lb-in. (789 Nm)

Total Tilt-Load Moment Requirement: 8,600 lb-in. (972 Nm)

CAUTION: THE SELECTION OF THE PROPER CHUCK, AND MOUNTING METHOD, AS WELL AS THE HOLDING OF THE WORK SHOULD BE DESIGNED BY QUALIFIED PERSONNEL. ALWAYS FOLLOW ALL MANUFACTURERS' RECOMMENDATIONS FOR THE USE OF ANY EQUIPMENT.

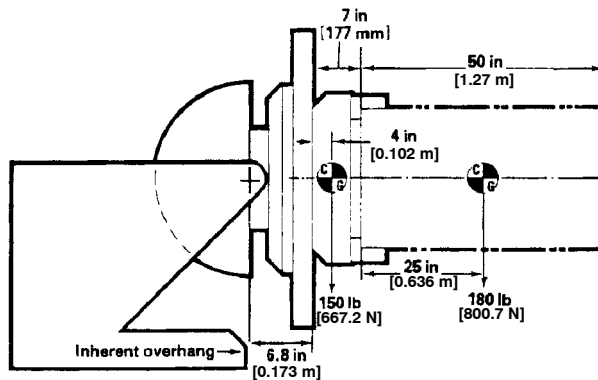


**Figure 8—Calculation of Total Tilt-Load Moment Requirements
(See Section II.A.4)**

(5) Work Lead Connections

Welding positioners have connections for attaching the work lead from the welding power source. Positioners are constructed with either current-carrying bearings or sliding brushes to carry the welding current from the work lead connections to the work table and to the weldment itself. This precludes having to connect the work lead cable directly to the weldment that could result in the cable becoming twisted or tangled as the table tilts or rotates. Ensuring a good electrical connection between the weldment and the table is another reason for securely clamping, bolting or welding the weldment to the positioner table.

Welding current can be transmitted through sliding brushes mounted in spring-loaded holders that bear against a surface on the rotating or tilting element of the positioner. These brushes can be made from copper, graphite, or copper-graphite matrix materials. Multiple brushes are used to provide the required current carrying capacity. Proper operation of these brushes requires that the surfaces of both the brushes and the rotating element must be clean and free from dirt or lubricants. Brushes, brush holders, and springs must be inspected periodically to be sure they are not worn or damaged.

Specially designed bearings also are used in positioners to carry the welding current to the work table. These bearings must be properly adjusted to prevent arcing or other damage that can degrade their current carrying ability.

Variations in arc voltage or arc length, an erratic arc, and changes in the weld bead size and shape can be indications of problems with the welding current circuit. The current path in the welding positioner is one area to be checked when these problems occur. The voltage drop across the positioner should be low (0.1V to 0.25V) and constant during welding. Any unusual fluctuations in voltage should be investigated and corrected.

(6) Floor Anchors

Most positioners are designed to be stable and to stand upright even when loaded to their full capacity. However, it is recommended that positioners be anchored to the floor to prevent them from tipping due to some unexpected event. For example, unexpected loads can occur when handling long workpieces that overhang the table of the positioner. Any potential for tipping of a positioner could be prevented by extending the floor base, but users prefer short bases that provide maximum swing clearance.

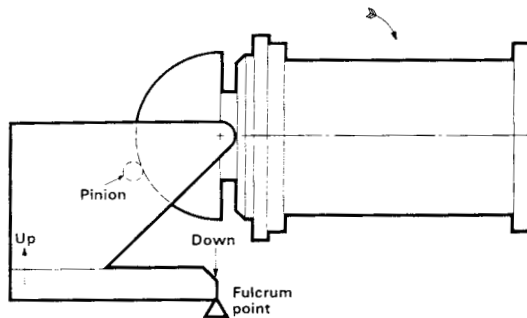


Figure 9—Force of Inertia on the Base of a Positioner

The transfer of momentum in a moving workpiece to the positioner when tilt movement suddenly stops can possibly cause it to tip over. Figure 9 shows the inertia force on a positioner base when the tilting workpiece is brought to a sudden stop. The front end of the base is the fulcrum point. The load is imposed downward. This means that the reaction load is upward at the rear of the base of the positioner. Figure 9 illustrates that it is only necessary to prevent the rear of the base from lifting to prevent the loaded positioner from tipping over. Anchoring only the rear of the base has further benefits. If the front of the base is not anchored, it can lift when the workpiece is accidentally tilted into the floor, reducing the load on the positioner gear train. This will not guarantee that the positioner gear train will not be harmed, but it might prevent serious damage.

Positioners have limit switches on both the tilting and rotating axes to limit the amount of movement of each axis. The correct procedure for handling a large workpiece is to adjust these limit switches to stop the positioner before the work can contact the floor.

CAUTION: THE LOCATION AND ANCHORING OF WELDING POSITIONERS SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. ALWAYS FOLLOW ALL OF THE RECOMMENDATIONS OF THE MANUFACTURER OF THE EQUIPMENT AND CONSULT THE MANUFACTURER REGARDING THE SUITABILITY OF ANY PARTICULAR APPLICATION.

B. Tilting-Rotating Positioners

Tilting-rotating positioners are the most common types of positioning equipment and can support loads weighing as little as 50 lb (89 N) and as much as 4,000 tons (3,636 M tons.). This type of positioner provides a table that rotates and tilts (see Figure 10) and permits positioning a wide range of even complex weldments. The table can be positioned so that the workpiece can be loaded when the table is horizontal and then tilted for access to individual weld joints. The table also rotates 360° to position weld joints and to provide travel along circumferential weld joints on curved or cylindrical parts. A variable speed drive is required if table rotation is to be used in this manner. Tilt axis drive systems are normally not used for weld joint travel and are therefore constant speed.

Tilting-rotating positioners are produced with several tilting mechanisms, depending on the needs of the application. The most common type can tilt the table from a horizontal position through a 135° angle, so the table and the mounted workpiece can tilt downward (see Figures 10 and 11). Other positioners also tilt 135°, but these models tilt 45° and 90° from the horizontal as shown in Figure 11. A final variation of a tilting-rotating positioner tilts 90° both ways from the horizontal table position. The table of this type of positioner does not rotate. Even though limited to a single 180° tilting motion, these positioners can be used advantageously for many types of work.

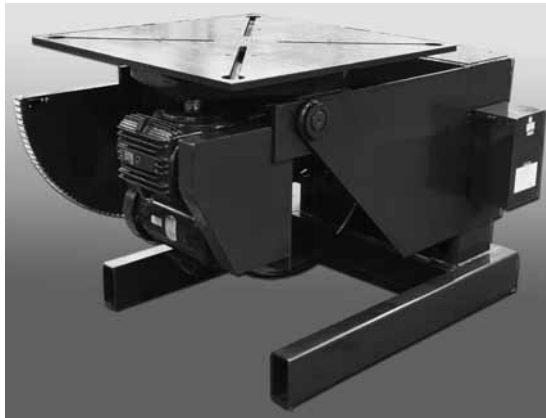


Figure 10—Typical 135° Tilting-Rotating Positioner with the Table in the Flat Position

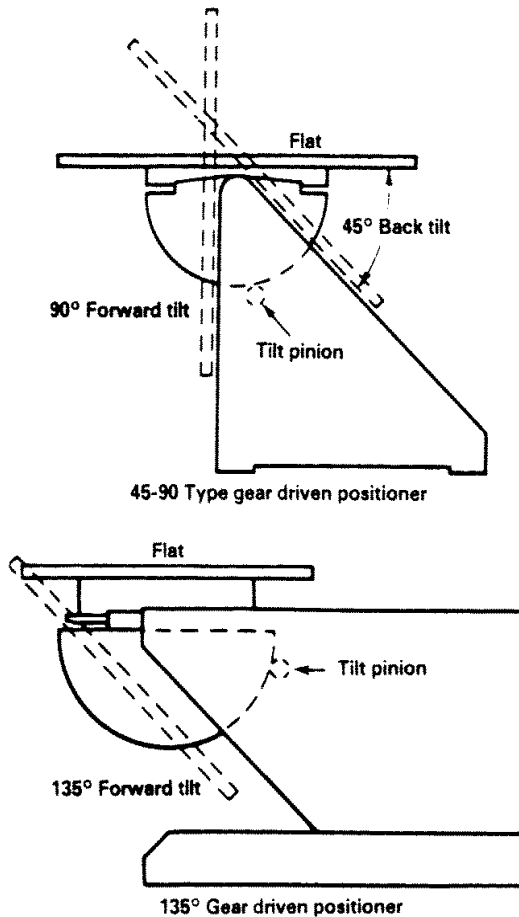


Figure 11—Examples of 45°–90° and 135° Tilting-Rotating Positioners

(1) Selecting Positioner Capacity

When selecting positioning equipment, both the weight of the workpiece and associated fixtures as well as the location of the center of gravity must be considered to determine the loads, moments, and torque required for each axis of motion (tilt and rotation.)

Figure 12 shows a typical tilting-rotating positioner in the 90° tilt position. The symbol in the circle with the letters “CG” is the standard symbol used for “center-of-gravity.” It indicates where the workpiece center of gravity is located relative to the surface of the positioner’s table. Note that there is another distance between the fulcrum, or tilt axis, and the surface of the table. This distance is called the “inherent overhang” of the positioner and is part of the design of any given machine. The inherent overhang distance must be added to the workpiece center of gravity distance to get the total distance that the weight of work acts through to put stress on the positioner tilting gears. These issues are covered in more detail in the sections that follow.

With an understanding of how torque ratings for positioners work, the proper load capacity can be selected to permit the positioner to handle the greatest torque requirement of the workpieces to be handled. The size and model of the positioner should be based on the greatest torque requirement, either tilt or rotation torque. Additional load capacity may be needed for other considerations such as inertia of a moving workpiece and shocks during loading of the positioner.

Load capacity ratings of positioning equipment are generally stated in terms of weight and distance from the center of gravity to the surface of the table. The load on the positioner is a combination of the weight of the workpiece and the moment due to this weight applied at the center of gravity distance.

Positioners have torque ratings for the rotary force they provide measured in “pounds-inches” (lb-in.) or the metric equivalent of Newton meters (Nm). This measure is derived from the fact that a moment is created when a weight in pounds (or Newtons) is imposed at a distance in inches (or meters) from the center point of rotation. A simple example of moment and torque can be seen when examining a teeter-totter. A 200 lb (889.6 N) person on one end of the teeter-totter at 48 in. (1.2m) from the fulcrum point would create a moment of 9,600 lb-in. (1,067 Nm). An equal moment could be created by placing a 100 lb (444.8 N) person 96 in. (2.4 m) from the fulcrum.

Another example would be to apply a 100 lb (444.8 N) force to a 6 in. (150 mm) wrench handle. This produces 600 lb-in. (67.8 Nm) of torque around the nut or fulcrum point. The same 100 lb (444.8 N) pull applied to a 12 in. (0.305m) long wrench will produce 1,200 lb-in. (135.7 Nm) of torque.

CAUTION: LOAD CALCULATIONS AND SIZING OF POSITIONING EQUIPMENT SHOULD BE PERFORMED BY A QUALIFIED ENGINEER. THE USER SHOULD ALWAYS FOLLOW ALL OF THE RECOMMENDATIONS OF THE MANUFACTURER OF THE EQUIPMENT AND SHOULD CONSULT THE MANUFACTURER REGARDING THE SUITABILITY OF THEIR EQUIPMENT FOR ANY PARTICULAR APPLICATION.

(2) Tilt Torque

Proper understanding of the torque requirements for the tilting axis is one of the most critical aspects of selecting a tilting-rotating positioner. To gain this understanding, look at Figure 13 that shows a 2,000 lb (8,896 N) weldment (W) with a center-of-gravity 12 in. (0.305 m) from the tilt axis (F) fulcrum point. The total moment on the positioner can be determined by multiplying the weight by the distance “F”:

$$12 \text{ in.} \times 2,000 \text{ lb} = 24,000 \text{ lb-in.} \quad (0.305 \text{ m} \times 8,896 \text{ N} = 2,713 \text{ Nm})$$