563-391-7700

ERCOLINA

NC & CNC MANDREL BENDERS

Prototype or Small Production Applications

Patented hydraulic finger (FST) clamp system minimizes distance between bends.

Part# 030-A3/H76
(10′ table displayed)

Mega Bender 030 with Mandrel System

Part#	Description
030-A15/H76	Mega Bender 030 with 5′ table
030-A3/H76	Mega Bender 030 with 10′ table
030-A6/H76	Mega Bender 030 with 20′ table
A15/H76	(5′) mandrel table only
A3/H76	(10′) mandrel table only
A6/H76	(20′) mandrel table only

FEATURES

- Variable bending speed
- Ideal for bending handrail, thin wall mild steel, stainless steel, bend grade aluminum and other materials
- Programmable bend sequencing and mandrel retraction
- Independent clamp and pressure die adjustment
- Reinforced tool mounting shaft with heavy duty swing arm for maximum rigidity
- Micrometer wiper die adjustment
- Secondary hydraulic pressure die stabilization system
- Quick-change tooling reduces setup time
- Tables available in 5′, 10′ or 20′ lengths; standard with pneumatic material clamping and DRO system for linear and rotational positioning
- Bending software available for part layout guideline
- Base machine converts to accept Ercolina non-mandrel tooling
- Reference display of Y & B axis to assist set-up
- Y - Feeding manual with adjustable stops
- B - Feeding manual with adjustable stops
- C - NC programmable bend angle

030 MANDREL BENDER

NC SEMI-AUTOMATIC ROTARY DRAW MANDREL BENDER

030 Mandrel Capacities & Specifications

Max. Tube Capacity – Mild Steel	2½″ (.083 wall)
Stainless	2½″ (.065 wall)
Square Tube	2″ (.065 wall)
Max. Pipe Capacity	1½″ Sch. 40
Max. Bending Radius	7⅞″
Min. Bending Radius	1.5 x Ø
Max. Shaft Rotation	210°
Max. Bending Angle	180°
Max. Tailstock Capacity	2⅜″
Max. Material Length – 5′ table	59″
10′ table	118″
20′ table	240″
Mandrel Table (available in 5′-10′-20′ lengths)	165″
Number of Programs	(30) Standard
Precision of Bend Angle	+/- 1°
Power	Three Phase 220V or 480V
Dimensions (Height x Width x Length)	44″ x 32″ x 83″-260″
Weight	1,600 lbs.

Contact CML USA for complete technical specifications.
All capacities based on mild grade materials; heavy wall and high tensile materials reduce machine capacity.

Zandeuk/Bigstock.com

◀ **Ercolina Bending Application**

Product Demonstrations Available on Website

NEED ADDITIONAL HELP? CONTACT ERCOLINA:

563.391.7700

info@ercolina-usa.com

Ideal for Prototype or Daily Production

Part# TB80-A/P80NC

FEATURES

- Control swings out to offer easy access to manual and auto operating modes, system diagnostics and multiple languages
- Unlimited storage of bend programs, material library and job information (optional)
- Touch screen displays absolute (ABS) or incremental (INC) positioning with inch or metric readout
- Programmable C axis with manual Y and B positioning
- Variable bending speed to 3 RPM with overload protection
- Programmable bend angle 0 to 180°
- Individual material springback and speed settings for every bend angle
- Anticipated mandrel retraction, clamping, pressure die and boost die movements
- Pressure die with auto recapture minimizes distance between bends
- Heavy duty tailstock carriage with segmented collet hydraulic clamping of work piece
- Tailstock Y and B position display resets to zero after each bend for easy setup while maintaining absolute position
- Bending head adjusts horizontally to maintain center-line radius of former allowing table to remain stationary
- Patented finger style (FST) clamping system minimizes distance between bends
- Direct drive electro-mechanical bending axis

TB80 MANDREL BENDER

NC SEMI-AUTOMATIC ROTARY DRAW MANDREL BENDER

TB80 Mandrel Capacities & Specifications

Max. Tube Capacity – Mild Steel Stainless Square Tube	3″ (.125 wall) 3″ (.083 wall) 2½″ (.083 wall)
Max. Pipe Capacity	2½″ Sch. 10
Max. Bending Radius	8.8″
Min. Bending Radius	1.5 x Ø
Max. Shaft Rotation	210°
Max. Bending Angle	180°
Max. Tailstock Through Capacity	3″
Max. Material Length – standard table Optional Table Extension	13′ 21′
Program Storage	USB Optional
Precision of Bend Angle	+/- 1°
Power	Three Phase 220V or 480V
Dimensions (Height x Width x Length)	61″ x 36″ x 179″ or 251″
Weight (13′ or 21′ table)	2,000 lbs. or 2,600 lbs.

Contact CML USA for complete technical specifications.
All capacities based on mild grade materials; heavy wall and high tensile materials reduce machine capacity.

- Precision encoders on all axes for greater repeatability
- Heavy one-piece steel structure improves rigidity and minimizes vibration
- Externally mounted gauges for adjustment of system and clamping pressure
- Accepts standard 030 mandrel tooling
- Electrical components UL, CSA and CE approved
- Programmable internal lubrication available
- Y - Feeding manual with adjustable stops
- B - Feeding manual with adjustable stops
- C - NC programmable bend angle
- Accepts optional mandrel lubrication pump

Patented finger style (FST) clamping system minimizes clamping area.

Fully Automatic – Cost Effective

Y & B Servo Positioning

Space underneath the work head completely free!

Part# EB76CNC6V5

FEATURES

- Extended bending head capable of bending complex shapes and profiles
- Automatic or manual bend sequencing
- Independent pressure and clamp die adjustment
- Programmable carriage movement for tight radii
- Interactive touch screen with auto and manual operating modes, system diagnostics and multiple language capability
- Standard right hand bending direction
- Programmable material springback settings for each bend angle
- Programmable auto mandrel positioning allows operator to optimize extraction for improved bend quality
- Programmable tail stock interference zone monitors position and eliminates workhead collision
- USB for unlimited program memory storage and communication
- Tangent or centerline programming
- Hand-held remote bending control, certified class 3 safety and all electrical components UL, CSA and CE approved
- Graphic bend simulation software included

EB65 & EB76 MANDREL BENDER

CNC AUTOMATIC 3 AXIS MANDREL MACHINES

EB65 & EB76 Capacities & Specifications

Model	**EB65**	**EB76**
Max. Tube Capacity – Mild Steel Stainless Square Tube	2½″ (.083 wall) 2½″ (.065 wall)	3″ (.083 wall) 3″ (.065 wall) 2″ (.065 wall)
Max. Pipe Capacity	1½″ Sch. 40	2″ Sch. 40
Max. Bending Radius	9.8″	9.8″
Min. Bending Radius	1.5 x Ø	1.5 x Ø
Max. Shaft Rotation	210°	210°
Max. Bending Angle	185°	185°
Max. Tailstock Capacity	2½″	3″
Interactive Touch Screen Control	10″ color screen	10″ color screen
Max. Material Length – Standard table Optional Table Extension	13′ 21′	13′ 21′
Minimum Underhead Swing Clearance	14.5″	15.5″
Length of Bending Head	59″	59″
Maximum Carriage Travel	125″	125″
Number of Programs	Unlimited	Unlimited
Precision of Bend Angle	+/- .5°	+/- .5°
Power	Three Phase 480V	Three Phase 480V
Dimensions (Height x Width x Length)	52″ x 44″ x 205″	52″ x 44″ x 205″
Weight	7,200 lbs.	7,400 lbs.

Contact CML USA for complete technical specifications.
All capacities based on mild grade materials; heavy wall and high tensile materials reduce machine capacity.

- Programmable internal mandrel lubrication (3 settings)
- High capacity with auxiliary hydraulic oil cooling
- Quick-change tooling system
- Standard 13′ table, extension available
- Tail stock with through spindle accepts longer material
- Accepts YBC and XYZ input values
- Y - Feeding Electric Servo
- B - Rotation Electric Servo
- C - Bending Hydraulic CNC
- Accepts optional mandrel lubrication pump

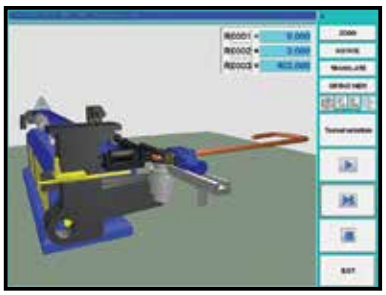
ERCOLINA® HANDRAIL FABRICATION SYSTEM

Ercolina's handrail professional series package includes:

- ☑ **Erco Bender three axis CNC automatic bending machine**
- ☑ **1-1/4″ pipe schedule 40 set complete**
- ☑ **1-1/2″ pipe schedule 40 set complete**
- ☑ **1-1/2″ tube for .120 wall set complete**
- ☑ **Auto mandrel lubrication pump**
- ☑ **Bendtech software for external computer**
- ☑ **Machine training on-site**

- Produce handrail to design in minutes
- Dramatically reduce operator handling and shop labor cost
- Improve quality to your customers providing mandrel quality bends in steel, stainless and aluminum
- Eliminate additional cost of weld elbows, material waste, weld, grind and finish operations
- Control your production time and process
- Quickly store and recall previous handrail programs
- Ercolina's tool set data files maintain machine start position enabling the operator to quickly change to the next job
- Optional software available directly imports properly formatted IGES and Dxf engineering files from compatible CAD programs
- Create your own data with optional Bend-Tech software
- Professional on-site machine training included

Erco Bender Interactive Touch Screen Control Panel



GRAPHIC SIMULATION

PART LAYOUT

TOUCH SCREEN PROGRAMMING

MAIN SCREEN

BEND ANGLE & SPRINGBACK

STORE ALL TOOL SET INFORMATION

STORE MATERIAL INFORMATION

Interactive CNC Control Available on these Models:

- Erco Bender 65
- Erco Bender 76

OPTIONAL BENDING SOFTWARE

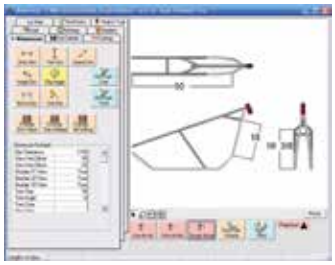
Quickly layout and produce drawings for bending applications!

Part# **BENSW-SUPER**

Reduce layout cost

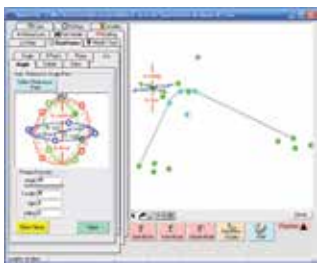
FEATURES

- Eliminate unnecessary material scrap
- Previous layout and design experience not required
- Mouse pick points allow dimension placement
- Dimension with decimals or fractions
- Save part program files for later use
- Information material data base included
- CLR or inside radius (adjustable for each bend)
- Create printable dimensioned model, shaded model, flat layout & title block
- Flat layout of cut length & bending locations
- Can be dimensioned from start of bend, end of bend & center of bend, or either direction
- Provides springback bend angle
- Print includes bending data such as bend angles, CLR or inside radius, rotation angle & bend order
- Preferences: color, text size & arrow size are saved in user definable data bases
- Verifies sufficient material is available for bending process
- Extra checking tools provided to verify part validity
- Allows multiple dies to be used on the same part
- Graphical layout interface provided
- Advanced LRA “Length, Rotation & Angle” design interface
- Powerful reverse engineering feature
- Inch to metric conversion
- CD-ROM Windows XP or higher required
- All standard Ercolina tooling included in tooling library
- LRA: transfers any part into XYZ data when entering LRA information into Custom Part interface; XYZ data available
- Railing Templates: includes hand railing template
- Chord measuring tool for large radius bending
- File Import/Export
- Estimating: Helps define project cost



Assembly Drawing

XYZ



HANDRAIL SIMULATION SAMPLES

Wall Rail

Material: 1¼" Schedule 40
Tooling: 1.660 Pipe R90
CLR: 3.5
Cal. CLR: 3.550
Cut Off Start End: 5.25
Cut Off Far End: 5.25

Shop Instructions:

Cut Length: 132 5/16

A	B	Location	Rotation	Angle	CLR
1	1	4 1/4	0	90	3.5
2	2	17 3/16	(-90)	32	3.5
		Flip			
4	3	128 1/16	(-90)	90	3.5
3	4	115 1/16	(-90)	32	3.5

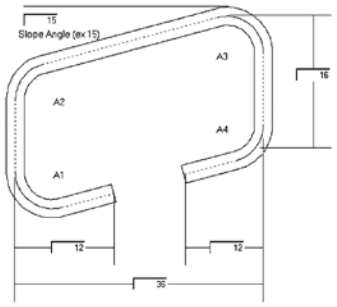
Design Instructions: Custom Part

Cut Length:

A	Length	Rotation	Angle	Type
1	2.5	0	90	Apex
2	12	-90	32	Apex
3	96	180	32	Apex
4	12	-90	90	Apex
E	2.5			

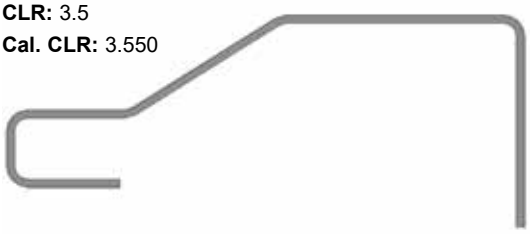
Bleacher

Material: 1¼" Schedule 40
Tooling: 1.660 Pipe R90
CLR: 3.5
Cal. CLR: 3.550



Handicap Rail

Material: 1¼" Schedule 40
Tooling: 1.660 Pipe R90
CLR: 3.5
Cal. CLR: 3.550



Shop Instructions:

Cut Length: 181 5/16

A	B	Location	Rotation	Angle	CLR
5	1	18 1/2	0	90	3.5
4	2	31	0	90	3.5
3	3	55 15/16	180	32	3.5
2	4	91 7/8	180	32	3.5
1	5	137 5/16	0	90	3.5

Design Instructions: Custom Part

Cut Length:

A	Length	Rotation	Angle	Type
1	42	0	90	Apex
2	48	0	32	Apex
3	36	0	-32	Apex
4	24	0	90	Apex
5	14	0	90	Apex
E	22			

	Location	Rotation	Bend
Bend Number: 1 Location: 18 1/2 Rotation: 0 Bend Angle: 90			
Bend Number: 2 Location: 31 Rotation: 0 Bend Angle: 90			
Bend Number: 3 Location: 55 15/16 Rotation: 180 Bend Angle: 32			
Bend Number: 4 Location: 91 7/8 Rotation: 180 Bend Angle: 32			
Bend Number: 5 Location: 137 5/16 Rotation: 0 Bend Angle: 90			

MODEL COMPARISON GUIDE

Model	030 Mandrel Bender	TB80 Mandrel Bender	Erco Bender 65 / 76
OPERATOR CONTROL			
LCD with PLC touchpad	✓		
Color touch screen		✓	✓
Independent control of Clamp, Mandrel Functions	✓		
Manual override control of Clamp, Pressure Die, Boost, Mandrel, Clamp release function		✓	✓
Inch or Metric display	✓		
Inch and Metric programming and display		✓	✓
Manual or Semi Auto mode	✓	✓	
Manual, Semi Auto and Auto modes			✓
PROGRAMMING			
(30) programs - up to (9) bend angle and springback settings per program	✓		
Unlimited program storage with USB		✓	✓
MACHINE DESIGN			
C axis electro mechanical operation with gear reduction. Main frame aluminum case.	✓		
C axis electro mechanical operation with planetary reduction. Main frame GS500 cast steel case.		✓	
C axis hydraulic operation with rack and pinion. Main frame GS500 cast steel case.			✓
Analog encoders for C axis, Counter Die Axis display position on control. LED on table to monitor length and rotation from original bend plane (YB).	✓		
Digital encoders for three axis with digital display of absolute or incremental position on touch screen.		✓	✓
Tailstock pneumatic clamping with four interchangeable jaw sets. 2⅜″ capacity.	✓		
Tailstock hydraulic clamping with segment collet. 2″ through spindle capacity, 3″ material capacity with collet.		✓	
Tailstock hydraulic clamping with segment collet. 2⅜″ through spindle capacity, 3″ material capacity with collet.			✓
Programmable mandrel retraction	✓	✓	✓

Factory on-site training available.
Contact CML USA for complete technical specifications.
All capacities based on mild grade materials; heavy wall and high tensile materials reduce machine capacity.

MANDREL TOOLING ORDER FORM

Fax Completed Form To: (563) 391-7710

Company Name: _____ Contact: _____ Date: _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____ Email: _____

Distributor Name: _____ Contact: _____

Material Specifications:

Tube/Pipe Dimensions: _____ OD _____ ID

Wall Thickness: _____

Material Type/Grade: _____

Weld Seam: _____ Yes _____ No

No. Parts Per Day: _____ No. Bends Per Part: _____

Prints Supplied: _____ Yes _____ No

Are Mill Certs Available _____ Yes _____ No

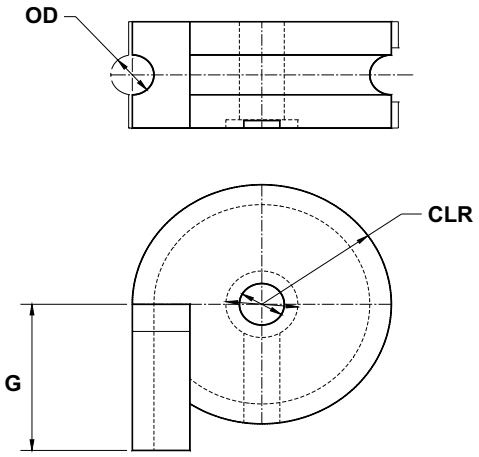
Centerline Radius (CLR): _____

Min. Dist. Bet. Bends (G): _____

Outside Diameter (OD): _____

Maximum Degree of Bend: _____

Center Former



Mandrel Information:

Mounting Thread on Mandrel (MT): _____

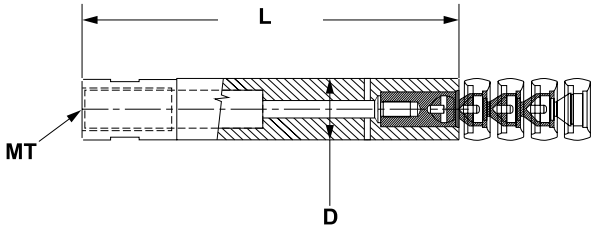
Length of Shank (L): _____

Number of Spheres Required: _____

Diameter of Mandrel (D): _____

Mandrel Material: _____ AMPCO Bronze _____ Steel/Chrome Plated

Mandrel



Pressure Die: _____ Steel _____ Polymer

Wiper Die Required: _____ Yes _____ No

Clamp Die: _____ Smooth _____ Serrated

Notes: _____

_____

_____

_____

I have reviewed the above information for accuracy and confirm it is correct. Any alterations made from original information will result in additional cost and may extend delivery time.

_____ _____

Customer Signature Date

When is a Mandrel Necessary?

When a tube is bent the outside wall collapses and thins out, and the inside compresses. When bending thin wall tube to tight radius a mandrel and wiper die are necessary. Use of a mandrel minimizes the amount of ovality occurring during bending.

Machine and tooling basics

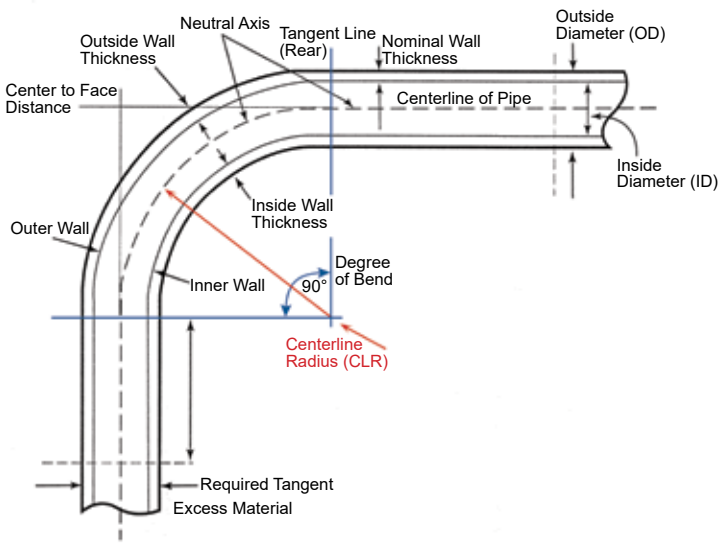
Machine capacity and features will vary based on application and production requirements. Ercolina produces both NC and CNC machines designed to accommodate job shop to moderate production applications. The correct selection of machine model, tooling and material will ensure success in bending, There are many factors to consider with selecting tooling. Generally parts with several bends or higher quantity may require a CNC machine. Parts with one centerline radius are the easiest to accommodate. Always encourage designer of the parts to use a single bend radius when possible. Most applications can modify the radius with little effect on the overall part design and make the bending process more productive. Using the largest possible radius will closely maintain shape of the material after the bend. Ideally mandrel bending to radius 2-3 times material diameter will yield the best results. Ercolina standard tooling sets are available in 2D and radius is base centerline radius (CLR).

Information required for mandrel tooling applications

- Size and wall thickness of material
- Material type and grade
- Number of bends on part
- Distance between bends
- Plane of bend relationship to one another
- Production rates
- Part tolerances
- Centerline radius of the bends. ***Note:*** bends with radius less than 2 times OD require greater attention, high grade bendable materials and heavier machine design.

Understanding material to be bent

Bending application success is dependent on several factors including and most importantly the proper material. Obtain a print of work to be done, review dimensions and tolerances. Review the mill certification for material from the mill and confirm the material is appropriate for bending. Use caliper to measure material and confirm dimensions are correct for tooling. Tube OD and wall thickness variations are far more common than you may realize. For some tube fabricating applications, this variation is of little concern, but in mandrel bending, ID dimension variation is a big issue. The tubing must fit the tooling and mandrel correctly and have the appropriate clearances. ***Note:*** tubing with no or minimal internal seam is preferred with mandrel bending. Material with heavy weld seam will interfere with mandrel and require tooling modification. Different types of material can be bent i.e., steel, aluminum, and stainless however the tooling composition and CLR may change to ensure material compatibility. Pay attention to material ordered and confirm it's received as ordered.



Terminology

Bend Specifications

OD is tube outside diameter, usually measured in inches or millimeters. Sometimes the tube outside diameter is expressed in nominal, such as IPS for pipe. Only rarely is a tube diameter specified as an inside diameter. This is non-standard, leads to confusion, and should be avoided. Whatever units are used, OD should be expressed in decimal, to three places in the case of inches.

WT is wall thickness. Inches and millimeters are common units, and again the precision of a decimal number to three places is warranted if inches are used; at least one place for millimeters. Frequently, the old Birmingham Wire Gage Standard is used to express WT; be sure to use the correct gage (there are several standards) when translating to decimal inches. When the TOD is expressed as an IPS nominal size, then the WT is expressed as a schedule number, which corresponds to a precise value in inches.

CLR is centerline radius and is the most common reference for bend radius. Again, inches and millimeters are the common units of measurement. Typically, fractional or two-place decimal inches are sufficiently precise. Sometimes the CLR is expressed as a multiple of the TOD, such as “1-D”, “2-D”, and so on. Note that if the TOD is expressed as an IPS nominal size and the CLR is expressed as a “D”, it is a multiple of the nominal, not the actual tube diameter. Inside radius, abbreviated “ISR”, is a common reference for specifying bend radius if the tubing is non-round. Outside radius is seldom used to define the bend radius.

DOB is degree of bend, often loosely referred to as the sweep of bend or depth of bend. This defines in decimal degrees (occasionally degrees and minutes) the arc of the bend. This is, of course, different from “plane of bend” or “orientation”, a specification for multi-bend parts which defines in degrees where the plane of the current bend is located relative to the plane of the first bend.

In defining multi-bend parts, XYZ rectangular coordinates are used, from which bend data are developed. Bend data consist of tangent length, plane of bend, and degree of bend and defines the motion of the tube during the bending process.

Geometry

All bent parts consist of arcs and tangents. The arc is simply the bent portion of the tube, and the tangent the unbent portion.

Inside radius (ISR) and outside radius (OSR) are nominal references defining the extreme inner and outer limits of the tube arc. The centerline radius (CLR) is, of course, the average of these two.

Plane of bend is the plane defined by the inside and outside radiuses.

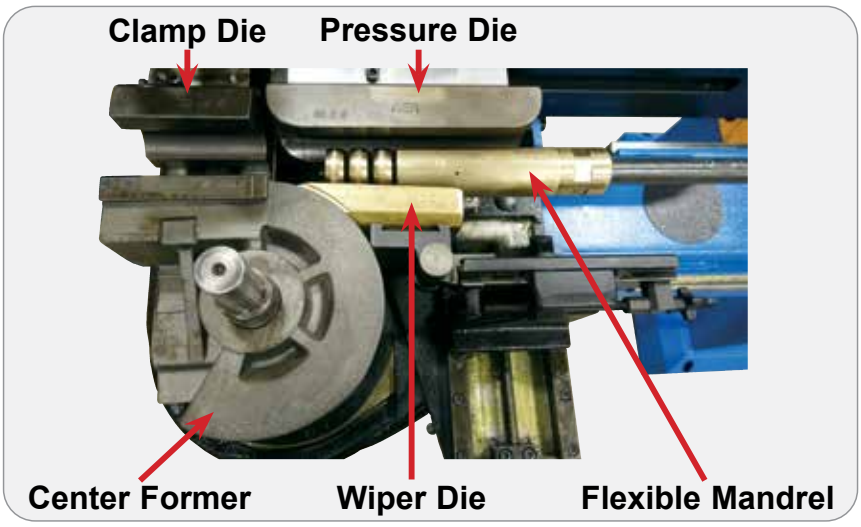
Line of tangency is actually a plane, perpendicular to the plane of bend, passing through the origin of the bend and the beginning point of the bend (in other words, it separates the arc of the bend from the tangent section). Before the line of tangency, the tube is straight. Past the line of tangency, it is bent. In draw bending, the line of tangency is fixed in space, through which the tube is drawn around the bend die as it rotates.

Neutral axis vs. centerline radius. It happens that the neutral axis is physically close to the centerline radius, but these terms are not synonymous. The neutral axis is a narrow region, lying inside of the centerline radius, separating the zone of compression from the zone of stretching. At the neutral axis the tube wall neither compresses nor stretches.

Intrados vs. inside radius. The intrados is the zone of compression, bounded by the inside radius and the neutral axis.

Extrados vs. outside radius. The extrados is the zone of stretching, bounded by the outside radius and the neutral axis.

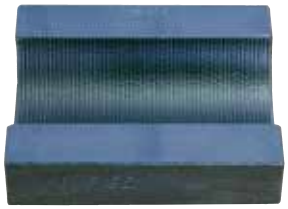
MANDREL TOOLING INFORMATION



Ercolina mandrel systems incorporate five (5) individual tooling components to effectively support the profile during bending process. These components; **Center former**, **pressure die, clamp die, wiper die and flexible mandrel** are specific to material type and dimension.

TOOLING COMPONENTS OF MANDREL BENDING

Center Former / Bend Die: Primary tool which determines bend radius. Manufactured from tool steel or alloy steel and heat treated depending on requirements. Clamp face is serrated to assist grip strength.



Clamp Die: Matches center former clamp surface. The clamp die's primary function is to hold tube securely to the center former.

Pressure Die: Maintains constant pressure on tube at tangent where the bend occurs, providing reactionary force to make the bend. Length of the pressure die depends on the degree of bend (DOB) of part being bent and the machine design.

Wiper Die: Manufactured to match center former radius. Mounts into the groove of the center former with tip positioned near tangent point of bend. Primary function is to prevent wrinkling on the inside radius of the tube. Wiper dies are typically manufactured from AMPCO® bronze.

Mandrels: Generally made from the same material as the wiper die. Primary function of the mandrel is to prevent inside diameter of the tube from collapsing. Choosing the correct mandrel is very important in determining the quality of bend. Three basic styles of mandrels are:

1. ***Plug mandrel*** used for heavier walled tube or large CLR bending.
2. ***Thin wall mandrel (close pitch mandrel)*** used mostly for thin wall tubing. Thin wall style mandrels use the same style linkage as standard mandrels except the link size is the next size smaller than it would be on a standard mandrel. For example, where a standard style mandrel would use a #10 size link, a thin wall style mandrel would use a #9 size link. The ball segments are now closer together and provide more support needed for thin walled tube bending. Strength is sacrificed for more support.

2″ Stainless Steel
.065 wall – 3″ CLR
Cutaway to show mandrel

Spring Collet

Segmented Collet

Collet: The collet is mounted in the tailstock of machine and holds material securely in carriage. Collets are size-specific and must match the tooling mounted on machine.

Bending Lubrication: Comes in several different forms such as oil, grease, and paste. The kind of lubrication used will depend on material to be bent. A generous amount of lubrication may be applied to mandrel and inside of tube, however precautions should be taken to avoid getting lubrication on center former and clamp die. Proper lubrication is important to making good bends.

Bending lubricant is a must in most applications. Proper lubricant will significantly improve the bending process and part quality. After you bend the tube, you're probably going to clean it, weld it, or assemble. Select and use the correct lubricant.

Stainless steels have higher tensile strengths and yield strengths than carbon steels, and require more energy generating more heat. Heat builds up, lubricant moves away from bend. Use lubricants with additives that reduce the amount of heat generated.

MOUNTING MANDREL TOOLING INSTRUCTIONS

030 Mandrel	TB80 Mandrel	Erco Bender
YouTube	YouTube	YouTube

STANDARD PIPE MANDREL TOOLING SETS

MATERIAL	WALL	CLR	ITEM CODE	DESCRIPTION	FITS MODEL
1″ Pipe		2.5″	AK20DP1000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR67R067P1000	*Center Former*	
			A224P1000	*Clamp Die*	
			A244R067P1000	*Wiper Die*	
			A204P1000	*Pressure Die*	
1″ Pipe Sch. 5	.065		AXKITSP1000065	Mandrel Flexible **STEEL CHROME** with Sphere	
1″ Pipe Sch. 10	.109		AXKITSP1000109		
1″ Pipe Sch. 40	.133		AXKITSP1000133		
1″ Pipe Sch. 5	.065		AXKITBP1000065	Mandrel Flexible **BRONZE** with Sphere	
1″ Pipe Sch. 10	.109		AXKITBP1000109		
1″ Pipe Sch. 40	.133		AXKITBP1000133		
1″ Pipe			EB068P1000	Spring Collet Tailstock	EB65
1″ Pipe			EB76P1000	Segmented Collet	EB76
1″ Pipe			GB90COP1000	Segmented Collet	TB80 Mandrel
1-1/4″ Pipe		3″	AK20DP1250	*Tool Set (Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR84R076P1250	*Center Former*	
			A2212P1250	*Clamp Die*	
			A2412R076P1250	*Wiper Die*	
			A2012P1250	*Pressure Die*	
1-1/4″ Pipe Sch. 5	.065		AXKITSP1250065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/4″ Pipe Sch. 10	.109		AXKITSP1250109		
1-1/4″ Pipe Sch. 40	.140		AXKITSP1250140		
1-1/4″ Pipe Sch. 5	.065		AXKITBP1250065	Mandrel Flexible **BRONZE** with Sphere	
1-1/4″ Pipe Sch. 10	.109		AXKITBP1250109		
1-1/4″ Pipe Sch. 40	.140		AXKITBP1250140		
1-1/4″ Pipe			EB068P1250	Spring Collet Tailstock	EB65
1-1/4″ Pipe			EB76P1250	Segmented Collet	EB76
1-1/4″ Pipe			GB90COP1250	Segmented Collet	TB80 Mandrel
1-1/2″ Pipe		3″	AK20DP1500	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR84R076P1500	*Center Former*	
			A2212P1500	*Clamp Die*	
			A2412R076P1500	*Wiper Die*	
			A2012P1500	*Pressure Die*	
1-1/2″ Pipe Sch. 5	.065		AXKITSP1500065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/2″ Pipe Sch. 10	.109		AXKITSP1500109		
1-1/2″ Pipe Sch. 40	.145		AXKITSP1500145		
1-1/2″ Pipe Sch. 5	.065		AXKITBP1500065	Mandrel Flexible **BRONZE** with Sphere	
1-1/2″ Pipe Sch. 10	.109		AXKITBP1500109		
1-1/2″ Pipe Sch. 40	.145		AXKITBP1500145		
1-1/2″ Pipe			EB068P1500	Spring Collet Tailstock	EB65
1-1/2″ Pipe			EB76P1500	Segmented Collet	EB76
1-1/2″ Pipe			GB90COP1500	Segmented Collet	TB80 Mandrel
2″ Pipe		5″	AK20DP2000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR133R127P2000	*Center Former*	
			A2214P2000	*Clamp Die*	
			A2414R127P2000	*Wiper Die*	
			A2014P2000	*Pressure Die*	
2″ Pipe Sch. 5	.065		AXKITSP2000065	Mandrel Flexible **STEEL CHROME** with Sphere	
2″ Pipe Sch. 10	.109		AXKITSP2000109		
2″ Pipe Sch. 40	.154		AXKITSP2000154		
2″ Pipe Sch. 5	.065		AXKITBP2000065	Mandrel Flexible **BRONZE** with Sphere	
2″ Pipe Sch. 10	.109		AXKITBP2000109		
2″ Pipe Sch. 40	.154		AXKITBP2000154		
2″ Pipe			EB068P2000	Spring Collet Tailstock	EB65
2″ Pipe			EB76P2000	Segmented Collet	EB76
2″ Pipe			GB90COP2000	Segmented Collet	TB80 Mandrel

Decoding Bend Terms

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STANDARD TUBE MANDREL TOOLING SETS

MATERIAL	WALL	CLR	ITEM CODE	DESCRIPTION	FITS MODEL
1″ Tube		2″	AK20DT1000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR53R051T1000	*Center Former*	
			A223T1000	*Clamp Die*	
			A243R051T1000	*Wiper Die*	
			A204T1000	*Pressure Die*	
1″ Tube 16 Ga.	.065		AXKITST1000065	Mandrel Flexible **STEEL CHROME** with Sphere	
1″ Tube 14 Ga.	.083		AXKITST1000083		
1″ Tube 11 Ga.	.120		AXKITST1000120		
1″ Tube 16 Ga.	.065		AXKITBT1000065	Mandrel Flexible **BRONZE** with Sphere	
1″ Tube 14 Ga.	.083		AXKITBT1000083		
1″ Tube 11 Ga.	.120		AXKITBT1000120		
1″ Tube			EB068T1000	Spring Collet Tailstock	EB65
1″ Tube			EB76T1000	Segmented Collet	EB76
1″ Tube			GB90COT1000	Segmented Collet	TB80 Mandrel
1-1/4″ Tube		2.5″	AK20DT1250	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR67R064T1250	*Center Former*	
			A224T1250	*Clamp Die*	
			A244R064T1250	*Wiper Die*	
			A204T1250	*Pressure Die*	
1-1/4″ Tube 16 Ga.	.065		AXKITST1250065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/4″ Tube 14 Ga.	.083		AXKITST1250083		
1-1/4″ Tube 11 Ga.	.120		AXKITST1250120		
1-1/4″ Tube 16 Ga.	.065		AXKITBT1250065	Mandrel Flexible **BRONZE** with Sphere	
1-1/4″ Tube 14 Ga.	.083		AXKITBT1250083		
1-1/4″ Tube 11 Ga.	.120		AXKITBT1250120		
1-1/4″ Tube			EB068T1250	Spring Collet Tailstock	EB65
1-1/4″ Tube			EB76T1250	Segmented Collet	EB76
1-1/4″ Tube			GB90COT1250	Segmented Collet	TB80 Mandrel
1-1/2″ Tube		3″	AK20DT1500	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR84R076T1500	*Center Former*	
			A2211T1500	*Clamp Die*	
			A2411R076T1500	*Wiper Die*	
			A2011T1500	*Pressure Die*	
1-1/2″ Tube 16 Ga.	.065		AXKITST1500065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/2″ Tube 14 Ga.	.083		AXKITST1500083		
1-1/2″ Tube 11 Ga.	.120		AXKITST1500120		
1-1/2″ Tube 16 Ga.	.065		AXKITBT1500065	Mandrel Flexible **BRONZE** with Sphere	
1-1/2″ Tube 14 Ga.	.083		AXKITBT1500083		
1-1/2″ Tube 11 Ga.	.120		AXKITBT1500120		
1-1/2″ Tube			EB068T1500	Spring Collet Tailstock	EB65
1-1/2″ Tube			EB76T1500	Segmented Collet	EB76
1-1/2″ Tube			GB90COT1500	Segmented Collet	TB80 Mandrel
1-5/8″ Tube		3.25″	AK20DT1625	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR84R082T1625	*Center Former*	
			A2212T1625	*Clamp Die*	
			A2412R082T1625	*Wiper Die*	
			A2012T1625	*Pressure Die*	
1-5/8″ Tube 16 Ga.	.065		AXKITST1625065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-5/8″ Tube 14 Ga.	.083		AXKITST1625083		
1-5/8″ Tube 11 Ga.	.120		AXKITST1625120		
1-5/8″ Tube 16 Ga.	.065		AXKITBT1625065	Mandrel Flexible **BRONZE** with Sphere	
1-5/8″ Tube 14 Ga.	.083		AXKITBT1625083		
1-5/8″ Tube 11 Ga.	.120		AXKITBT1625120		
1-5/8″ Tube			EB068T1625	Spring Collet Tailstock	EB65
1-5/8″ Tube			EB76T1625	Segmented Collet	EB76
1-5/8″ Tube			GB90COT1625	Segmented Collet	TB80 Mandrel

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STANDARD TUBE MANDREL TOOLING SETS

MATERIAL	WALL	CLR	ITEM CODE	DESCRIPTION	FITS MODEL
1-3/4″ Tube		3.5″	AK20DT1750	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR100R089T1750	*Center Former*	
			A2212T1750	*Clamp Die*	
			A2412R089T1750	*Wiper Die*	
			A2012T1750	*Pressure Die*	
1-3/4″ Tube 16 Ga.	.065		AXKITST1750065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-3/4″ Tube 14 Ga.	.083		AXKITST1750083		
1-3/4″ Tube 11 Ga.	.120		AXKITST1750120		
1-3/4″ Tube 16 Ga.	.065		AXKITBT1750065	Mandrel Flexible **BRONZE** with Sphere	
1-3/4″ Tube 14 Ga.	.083		AXKITBT1750083		
1-3/4″ Tube 11 Ga.	.120		AXKITBT1750120		
1-3/4″ Tube			EB068T1750	Spring Collet Tailstock	EB65
1-3/4″ Tube			EB76T1750	Segmented Collet	EB76
1-3/4″ Tube			GB90COT1750	Segmented Collet	TB80 Mandrel
2″ Tube		4″	AK20DT2000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR110R102T2000	*Center Former*	
			A2213T2000	*Clamp Die*	
			A2413R102T2000	*Wiper Die*	
			A2013T2000	*Pressure Die*	
2″ Tube 16 Ga.	.065		AXKITST2000065	Mandrel Flexible **STEEL CHROME** with Sphere	
2″ Tube 14 Ga.	.083		AXKITST2000083		
2″ Tube 11 Ga.	.120		AXKITST2000120		
2″ Tube 16 Ga.	.065		AXKITBT2000065	Mandrel Flexible **BRONZE** with Sphere	
2″ Tube 14 Ga.	.083		AXKITBT2000083		
2″ Tube 11 Ga.	.120		AXKITBT2000120		
2″ Tube			EB068T2000	Spring Collet Tailstock	EB65
2″ Tube			EB76T2000	Segmented Collet	EB76
2″ Tube			GB90COT2000	Segmented Collet	TB80 Mandrel
2-1/4″ Tube		4.5″	AK20DT2250	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR121R114T2250	*Center Former*	
			A2214T2250	*Clamp Die*	
			A2414R114T2250	*Wiper Die*	
			A2014T2250	*Pressure Die*	
2-1/4″ Tube 16 Ga.	.065		AXKITST2250065	Mandrel Flexible **STEEL CHROME** with Sphere	
2-1/4″ Tube 14 Ga.	.083		AXKITST2250083		
2-1/4″ Tube 11 Ga.	.120		AXKITST2250120		
2-1/4″ Tube 16 Ga.	.065		AXKITBT2250065	Mandrel Flexible **BRONZE** with Sphere	
2-1/4″ Tube 14 Ga.	.083		AXKITBT2250083		
2-1/4″ Tube 11 Ga.	.120		AXKITBT2250120		
2-1/4″ Tube			EB068T2250	Spring Collet Tailstock	EB65
2-1/4″ Tube			EB76T2250	Segmented Collet	EB76
2-1/4″ Tube			GB90COT2250	Segmented Collet	TB80 Mandrel
2-1/2″ Tube		5″	AK20DT2500	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR133R127T2500	*Center Former*	
			A2215T2500	*Clamp Die*	
			A2415R127T2500	*Wiper Die*	
			A2015T2500	*Pressure Die*	
2-1/2″ Tube 16 Ga.	.065		AXKITST2500065	Mandrel Flexible **STEEL CHROME** with Sphere	
2-1/2″ Tube 14 Ga.	.083		AXKITST2500083		
2-1/2″ Tube 11 Ga.	.120		AXKITST2500120		
2-1/2″ Tube 16 Ga.	.065		AXKITBT2500065	Mandrel Flexible **BRONZE** with Sphere	
2-1/2″ Tube 14 Ga.	.083		AXKITBT2500083		
2-1/2″ Tube 11 Ga.	.120		AXKITBT2500120		
2-1/2″ Tube			EB068T2500	Spring Collet Tailstock	EB65
2-1/2″ Tube			EB76T2500	Segmented Collet	EB76
2-1/2″ Tube			GB90COT2500	Segmented Collet	TB80 Mandrel

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STANDARD TUBE MANDREL TOOLING SETS

MATERIAL	WALL	CLR	ITEM CODE	DESCRIPTION	FITS MODEL
3″ Tube		6″	AK20DT3000	Tool Set *(Includes 4 items:)*	TB80 Mandrel, EB76
			AR178R152T3000	*Center Former*	
			A2217T3000HR	*Clamp Die*	
			A2417R152T3000	*Wiper Die*	
			A2017T3000	*Pressure Die*	
3″ Tube 16 Ga.	.065		AXKITST3000065	Mandrel Flexible **STEEL CHROME** with Sphere	
3″ Tube 14 Ga.	.083		AXKITST3000083		
3″ Tube 11 Ga.	.120		AXKITST3000120		
3″ Tube 16 Ga.	.065		AXKITBT3000065	Mandrel Flexible **BRONZE** with Sphere	
3″ Tube 14 Ga.	.083		AXKITBT3000083		
3″ Tube 11 Ga.	.120		AXKITBT3000120		
3″ Tube			EB76T3000	Segmented Collet	EB76
3″ Tube			GB90COT3000	Segmented Collet	TB80 Mandrel

Decoding Bend Terms

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SQUARE TUBE MANDREL TOOLING SETS

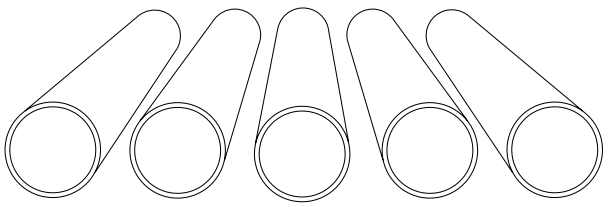
MATERIAL	WALL	CLR	ITEM CODE	DESCRIPTION	FITS MODEL
1″ Square Tube		3″	AK30DAT1000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR84R076A1000	*Center Former*	
			A223A1000	*Clamp Die*	
			A243R076A1000	*Wiper Die*	
			A203A1000	*Pressure Die - Steel*	
1″ Square Tube	.065		AXKITSA1000065	Mandrel Flexible **STEEL CHROME** with Sphere	
1″ Square Tube	.120		AXKITSA1000120	Mandrel Flexible **STEEL CHROME** with Sphere	
1″ Square Tube			EB068A1000	Spring Collet Tailstock	EB65
1″ Square Tube			EB76A1000	Segmented Collet	EB76
1″ Square Tube			GB90COA1000	Segmented Collet	TB80 Mandrel
1-1/2″ Square Tube		4.4″	AK30DAT1500	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR121R114A1500	*Center Former*	
			A2211A1500	*Clamp Die*	
			A2411R114A1500	*Wiper Die*	
			A2011A1500	*Pressure Die - Steel*	
1-1/2″ Square Tube	.065		AXKITSA1500065	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/2″ Square Tube	.120		AXKITSA1500120	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/2″ Square Tube			EB068A1500	Spring Collet Tailstock	EB65
1-1/2″ Square Tube			EB76A1500	Segmented Collet	EB76
1-1/2″ Square Tube			GB90COA1500	Segmented Collet	TB80 Mandrel
2″ Square Tube		6″	AK30DAT2000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR178R152A2000	*Center Former*	
			A2213A2000	*Clamp Die*	
			A2413R152A2000	*Wiper Die*	
			A2013A2000	*Pressure Die - Steel*	
2″ Square Tube	.065		AXKITSA2000065	Mandrel Flexible **STEEL CHROME** with Sphere	
2″ Square Tube	.120		AXKITSA2000120	Mandrel Flexible **STEEL CHROME** with Sphere	
2″ Square Tube			EB068A2000	Spring Collet Tailstock	EB65
2″ Square Tube			EB76A2000	Segmented Collet	EB76
2″ Square Tube			GB90COA2000	Segmented Collet	TB80 Mandrel

CuNi CLASS 200 MANDREL TOOLING SETS

MATERIAL	WALL	CLR	ITEM CODE	DESCRIPTION	FITS MODEL
1″ Pipe		4″	AK30DP1000	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR100R100P1000	*Center Former*	
			A224P1000	*Clamp Die*	
			A244R100P1000	*Wiper Die*	
			A20PUP1000	*Pressure Die - Polymer*	
1″ Pipe Sch. 5	.070		AXKITCUNIP1000070	Mandrel Flexible **STEEL CHROME** with Sphere	
1″ Pipe			EB068P1000	Spring Collet Tailstock	EB65
1″ Pipe			EB76P1000	Segmented Collet	EB76
1″ Pipe			GB90COP1000	Segmented Collet	TB80 Mandrel
1-1/4″ Pipe		5″	AK30DP1250	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR133R127P1250	*Center Former*	
			A224P1250	*Clamp Die*	
			A2412R127P1250	*Wiper Die*	
			A201P2P1250-18	*Pressure Die - Polymer*	
1-1/4″ Pipe Sch. 5	.072		AXKITCUNIP1250072	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/4″ Pipe			EB068P1250	Spring Collet Tailstock	EB65
1-1/4″ Pipe			EB76P1250	Segmented Collet	EB76
1-1/4″ Pipe			GB90COP1250	Segmented Collet	TB80 Mandrel
1-1/2″ Pipe		6″	AK30DP1500	Tool Set *(Includes 4 items:)*	030 Mandrel, TB80 Mandrel, EB65, EB76
			AR178R152P1500	*Center Former*	
			A2212P1500	*Clamp Die*	
			A2412R152P1500	*Wiper Die*	
			A201P1500-18	*Pressure Die - Polymer*	
1-1/2″ Pipe Sch. 5	.072		AXKITCUNIP1500072	Mandrel Flexible **STEEL CHROME** with Sphere	
1-1/2″ Pipe			EB068P1500	Spring Collet Tailstock	EB65
1-1/2″ Pipe			EB76P1500	Segmented Collet	EB76
1-1/2″ Pipe			GB90COP1500	Segmented Collet	TB80 Mandrel
2″ Pipe		7.125″	AK30DP2000	Tool Set *(Includes 4 items:)*	TB80 Mandrel, EB76
			AR200R180P2000	*Center Former*	
			A2214P2000	*Clamp Die*	
			A2414R180P2000	*Wiper Die*	
			A201P4P2000-18	*Pressure Die - Polymer*	
2″ Pipe Sch. 5	.083		AXKITCUNIP2000083	Mandrel Flexible **STEEL CHROME** with Sphere	
2″ Pipe			EB76P2000	Segmented Collet	EB76
2″ Pipe			GB90COP2000	Segmented Collet	TB80 Mandrel
2-1/2″ Pipe		8.625″	AK30DP2500	Tool Set *(Includes 4 items:)*	TB80 Mandrel, EB76
			EBDR219P2500	*Center Former*	
			A2216P2500	*Clamp Die*	
			A24/1/6P2500	*Wiper Die*	
			A201P6P2500	*Pressure Die - Polymer*	
2-1/2″ Pipe Sch. 5	.083		AXKITCUNIP2500083	Mandrel Flexible **STEEL CHROME** with Sphere	
2-1/2″ Pipe			EB76P2500	Segmented Collet	EB76
2-1/2″ Pipe			GB90COP2500	Segmented Collet	TB80 Mandrel

CuNi Size Chart

IPS		90/10 70/30	70/30			
	OD	CL 200 Wall	CL700 Wall	CL 1650 Wall	CL 3300 Wall	CL 6000 Wall
1″	1.315	0.065	0.095	0.095	0.180	0.300
1-1/4″	1.660	0.072	0.095	0.120	0.220	0.380
1-1/2″	1.900	0.072	0.109	0.134	0.250	0.425
2″	2.375	0.083	0.120	0.165	0.340	0.520
2-1/2″	2.875	0.083	0.134	0.203	0.380	



THE TOOLS MAKE THE BEND

Four simple steps for setting up a complete set of tools on a machine will maximize bend quality, tool life, and process control. Modern features on tube bending machines, especially pressure die assist, have permitted many tube bending machine operators to rely more upon manipulating machine controls to obtain adequate results than upon a precise, systematic tool set-up. Many optional controls on CNC tube bending machines, such as variable assist pressure, circumferential boost, and in-cycle mandrel retraction, were created to make the most difficult applications practical. However, they are instead frequently used to push material about at the point of bend to overcome the defects of a poor set-up on routine applications. Overreliance on the machine's controls "squeezes" the tube into the desired shape through excessive use of radial force from the pressure die at the point of bend. Because this approach works against the axial tension on the tube that is natural to the rotary draw process, high machine-actuated pressures must be used to force the part into shape. Use of high pressure at the point of bend often forces the machine operator to trade off tool life or process control in order to achieve acceptable bend quality.
A four-step set-up procedure that combines a forward mandrel position with lower machine pressures solves these problems.

The Four Step Set-up

This procedure will assist in precise position on the critical working surfaces of your tools relative to the point of bend so that under minimum pressure they will exploit the natural axial flow of the tubing material and guide it into the desired shape.

The four steps in a "Forward Mandrel, Low Pressure" set-up are:

1. Mandrel nose placement
2. Direct pressure die setting
3. Wiper tip rake
4. Pressure die assist setting

The trick to successfully implementing the four-step set-up is understanding that only one aspect of bend quality can be addressed at each step.

Accurate placement of the mandrel nose ensures a stable round cross-section throughout the arc of the bend. A correct direct (or radial) pressure setting of the pressure-die stops the buckling of the inside radius. A wiper tip properly raked from the line of tangency prevents the wrinkle or series of small wrinkles that can form at the terminal end of the inside radius. And finally a balanced pressure die assist setting will push out the outside radius sufficiently to mitigate flattening and to eliminate any terminal hump.

Furthermore, applying these steps in sequence will help overcome the common troubleshooting obstacle of one tool masking the failure of another – for example, excessive direct pressure die pressure covering up an improperly placed mandrel nose. The following descriptions of each step will clarify these troubleshooting issues.

Step #1: Mandrel Nose Placement

The mandrel is the central tool in the rotary draw bending set-up. It is your primary means of controlling the flow of tubing material at the point of bend. To understand the best placement of the mandrel nose it is useful to understand the difference between the line of tangency and the point of bend.

In this region the tube wall will thicken along the inside radius (intrados) and will thin along the outside radius (extrados) as the clamps draw the tube around the bend die. The purpose of the mandrel nose is to cover this region of flowing material and ensure a consistently round cross section by mitigating the simultaneous compression and stretching of the tube wall.

Because the point of bend extends past the line of tangency, so too must the mandrel nose to support it. If it does not, then the compression and stretching of the tube wall is uncontrolled. This results in buckling and excessive flattening.

While more direct pressure die (i.e. radial) pressure can often remedy the buckling along the inside radius, it will also exacerbate the flattening of the outside radius because of the additional drag it causes on the outside radius. Therefore, the mandrel nose placement past the line of tangency is critical, because it then can both eliminate buckling and minimize flattening.

There is a limit to how deep the mandrel nose can be placed past the line of tangency into the bend. At some point the outside line of the mandrel nose will intersect the outside radius of the tube bend and force the tubing material to form over the contour of the nose and perhaps the balls. What intuition does not tell us is that this point is relatively deep into the bend and that, in most instances, tube bending machine operators are not using the mandrel nose aggressively enough.

Several factors come into play in calculating how deep past the line of tangency the mandrel nose can be placed:

- Tube diameter
- Wall thickness
- Centerline radius
- Mandrel nose diameter
- Mandrel nose radius

If your mandrel nose is stable at the proper depth past the line of tangency and its diameter is not undersized for the application, then go onto the next step to determine the correct direct pressure-die setting. It is important to ensure that your mandrel nose is not undersized for the bend you want to make. There is a practical limit to how small a mandrel nose diameter can be and still be effective.

A properly sized mandrel nose is critical to mitigating flattening on the outside radius of the bend and buckling on the inside radius.

If you have other problems such as terminal wrinkles on the inside radius or a terminal hump on the outside radius, continue on. These problems will be fixed later in the set-up.

Step #2: Direct Pressure Die Setting

In this next step you will execute the “Low Pressure” principle. If you have set the mandrel nose sufficiently forward into the bend so that it does most of the work in controlling the shape of the tube, then the only work the pressure-die needs to do is to apply enough pressure so the tube does not pull away from the bend die during the bend. (If it does pull away, then the inside radius will buckle into the gap created.) Intuition suggests that not much pressure is needed to do this job.

The pressure die applies a radial force upon the tube at the point of bend. Because this radial force is perpendicular to the natural axial flow of material in the rotary draw bending process, drag results.

Too much drag and you will have terminal humps and excessive flattening of the outside radius. Too much drag is usually the culprit when the tube slips from the clamp dies. Your objective is to eliminate as much drag as possible by determining the lowest direct (radial) pressure needed to prevent buckling. Generally the more rigid the cross-section of the tube, the more direct pressure is needed to hold it against the pressure die.

Most mild steel, stainless steel, aluminum, and copper round tube applications 3 inches and under in diameter will require relatively low direct pressure to accomplish this (the actual setting varies with make and model of the tube bending machine).

Square and rectangular tubes (especially if bent the “hard way”) will require higher pressures. So will copper-nickel, super-alloy, and some nickel-stainless tubes. Unfortunately there is no simple formula for calculating the optimum setting because such factors as tube shape and size, wall thickness, centerline radius, degree of bend, and material rigidity must all be taken into account. An additional problem is that the pressure reading from the machine may not reflect what is actually applied to the tube.

If continuous wrinkling or a buckle forms on the inside radius, increase the direct pressure setting in increments of 10 to 20 KSI until this problem disappears. If there is no deformation on the inside radius, consider dropping the direct pressure. Once you determine the minimum direct pressure your application requires, you can rely upon this value for future set-ups of the same application and as a guideline to other applications.

At the end of this step you will have combined the “Forward Mandrel” and “Low Pressure” concepts behind this set-up to produce an acceptable bend. Some imperfections may still persist, such as a terminal inside radius wrinkle or terminal outside radius hump. These can be fixed by the last two steps of the set-up procedure.

Step #3: Wiper Tip Rake

The wiper's job is to prevent a wrinkle from forming at the end of the bend. Check whether or not there is a wrinkle at the terminal end of an otherwise smooth inside radius. If not, you do not need a wiper, and this step is completed. If so, the wiper tip needs to be positioned for optimal tool life.

The wiper fills the gap behind the line of tangency between the inside line of the tube and the curve of the bend die cavity. If the tube wall is not sufficiently rigid it will bulge outward to fill this gap. With enough direct pressure die pressure this bulge will flatten out between the bend die cavity and the mandrel nose as the tube is drawn through the line of tangency. But at the terminus of the bend the bulge is not drawn through and flattened, and it can then form a wrinkle, or small series of wrinkles, if the bulge extends far enough to exceed the elasticity of the tubing material.

Properly set, the tip of the wiper will catch the top of this terminal bulge before it sets into that wrinkle. Note that because all tubing materials have some elasticity, the bulge will to a certain extent flatten itself out once pressure is relieved from the point of bend.

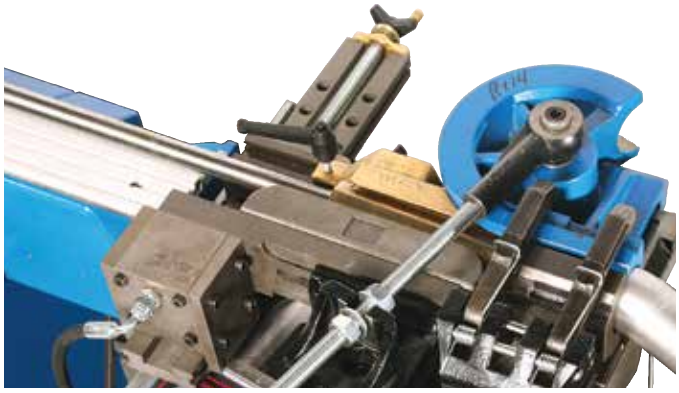
Therefore, it is not necessary for the wiper tip to contain the entire height of the terminal bulge. The wiper tip needs to obstruct only that marginal bulging which exceeds the material's elasticity and would set the entire bulge into a permanent wrinkle.

This is why a wiper can be raked away from the line of tangency. The value of raking the wiper is that doing so extends its life. The key to this step in the "Forward Mandrel, Low Pressure" set-up is finding the natural resting position of the wiper at zero rake and then determining the maximum rake that can be set for the application.

To do this, hold a straightedge at the bottom of the grip section of the bend die cavity. With the wiper loosely mounted on the wiper post, bring in the wiper so that the bottom of its cavity also lines up with the straightedge. The wiper is now at zero rake.

To find its natural resting position, gently slide the wiper along the straightedge towards the line of tangency until resistance is met. Check if the feathered edge of the wiper tip is in complete contact with the bend die cavity. If so, you have found the natural fit. If not, apply slightly more force until the feathered edge is securely backed by the bend die cavity. If you must use considerable force to find a "fit", most likely the wiper is improperly cut or you are trying to get the tip too close to the line of tangency. The latter is a common problem because to the eye it looks better when the wiper is at the line of tangency; however, most wipers are not cut to permit such a setting, nor is it necessary if the purpose of the wiper is limited to containing the terminal bulge.

Step #4: Pressure Die Assist Setting



Like the wiper, pressure die assist is not necessary if there are no remaining flaws for it to fix. In this case, if there is no terminal hump on the outside radius and the flattening is acceptable, you do not need pressure die assist. Turn it off or set it to a neutral pressure (depending upon your machine), and your set-up is complete. Otherwise start from a neutral pressure setting and increase the assist until the flaws disappear.

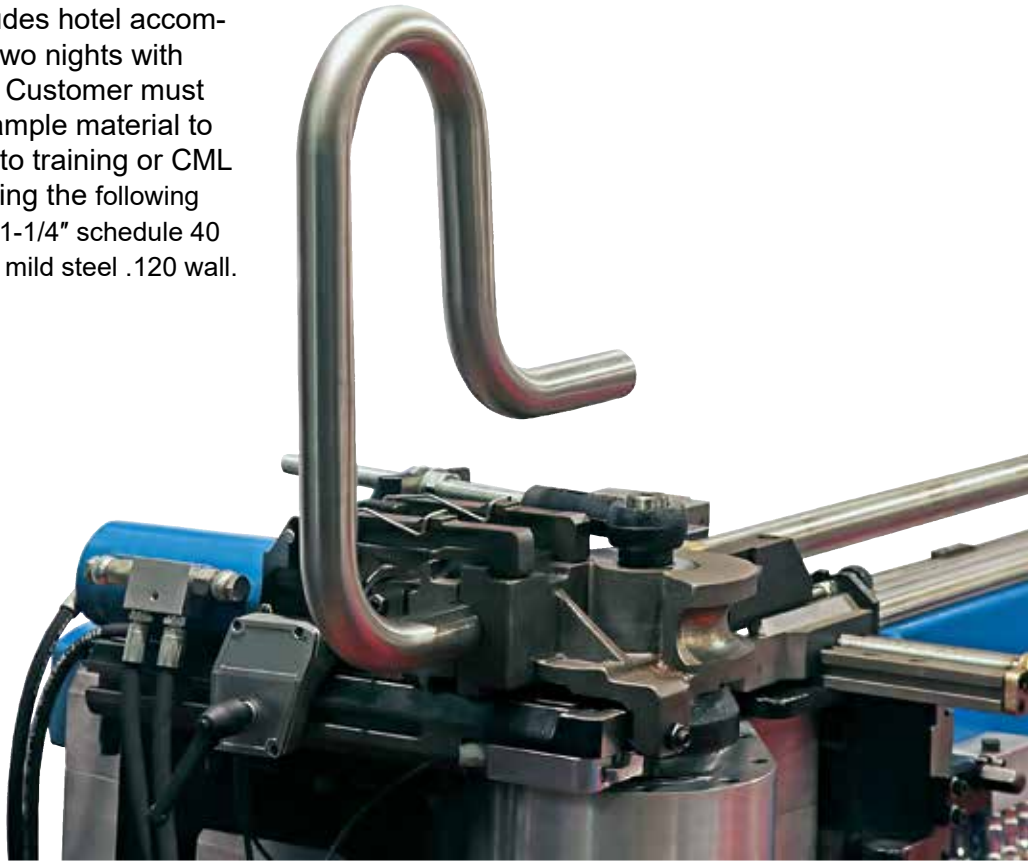
Trial and error with a limited range will determine the minimum pressure die assist setting to complete the “Forward Mandrel, Low Pressure” set-up. If a high or unstable setting results, it is necessary to re-examine the three preceding steps, because the assist setting is masking or unable to overcome the problem.

FACTORY TRAINING INCLUDED WITH MACHINE PURCHASE

Machine Operation Training 1-1/2 days completed at supplier location: 3100 Research Parkway, Davenport Iowa.

Includes review of machine components and operation, display functions, tooling selection, material review, proper mounting of tooling, tooling adjustments, introduction to programming, creating and storing program(s) to display, how to produce parts, standard required maintenance, and necessary connections, lubricates, fluids. General safety practices when using Ercolina machinery.

Factory training includes hotel accommodations for up to two nights with lunch provided daily. Customer must provide prints and sample material to CML USA, Inc. prior to training or CML will produce parts using the following material: A53 Grade A 1-1/4″ schedule 40 pipe or 1-1/2″ OD tube mild steel .120 wall.



MATERIAL OVERVIEW
COMMON TUBE AND PIPE

Pipe and tube are manufactured from a variety of metals are suitable for bending. However, different pipe materials have different physical properties which influence the bend. For example, copper is malleable and ready to bend at room temperature, whereas stainless steel requires a much greater effort to bend. Not only does pipe material influence the ease of bending, but it also influences how readily a pipe will take the desired shape or be damaged during the bending process. Most buyers don't even ask the question is this material suited for bending. Always start with the material and confirm it is acceptable for bending.

Carbon steel

The term carbon steel is often used to indicate steel that is not stainless steel, and is one of the most commonly bent materials. It is a strong, reliable component for construction (Figure 2) and OEM (original equipment manufacturer) applications. Carbon steel is available in different grades, offering various options in machining, bending, and wear resistance.

Mild steel

Mild steel is a commercial term that means low-carbon steel. It contains 0.04 - 0.3% carbon and therefore is more malleable and ductile. Ductility decreases as the carbon percentage in the steel increases. All machines are rated on mild steel capacity, bending higher tensile materials must be factored in sizing the machine model. Higher tensile strength materials require larger machines.

Alloy steel

Typical pipe material tensile strengths:

Grade A 48000 PSI (Machine rated for Grade A)
Grade B 60000 PSI
Grade C 70000 PSI

Two popular steel alloys are AISI 1018 and AISI 4140. The last two digits of each number indicate the percentage of carbon in the alloy: 1018 has 0.18% carbon and 4140 has 0.40% carbon. This means that 1018 is a mild steel and 4140 is a medium-grade carbon steel. AISI 1080 can be cold bended and AISI 4140 should be heat treated before bending.

Stainless steel

Material tensile strengths:

304 SS 73200 PSI

Different grades of stainless-steel range in carbon content from low-grade to high-grade (approximately 1% carbon content), but are differentiated from carbon steel by their high chromium content (minimum 10.5%). This high chromium content is what protects stainless steel from corrosion and rust. Of the different types of stainless steel, 300-series, specifically 304 stainless steel is the most popular for bending due to its ductility. However, at large diameters, stainless steel is very difficult to bend manually. A mandrel bending machine is typically used in this case.

Aluminum

Aluminum is lightweight, and the material requires specialized skills and forming processes to prevent material cracking. However, the bending properties vary according to the different grades of aluminum used. 6061 aluminum material is hard to bend, and cracking is pretty common. Cold bending always weakens the material. Proper bending can by using T0 temper material that is new from mill, or annealing aluminum first. 3003 aluminum is the best for bending due to its midrange strength and high elongation. It can be cold bent, and has a high difference between tensile strength and yield strength. This means it can be permanently deformed, in other words bent, a great deal before breaking. 5052 aluminum 5052 aluminum is almost as good for bending as 3003 aluminum, but has slightly less elongation. However, when heated, its formality improves past that of 3003 aluminum. Aluminum is commonly used in transportation and storage tanks. Always use the largest radius possible when bending aluminum to avoid breaking the material.

Copper Tube

Both annealed tube and hard drawn tube can be bent with the appropriate machine and tooling. Material grade, wall thickness and minimum CLR must all be considered before bending.

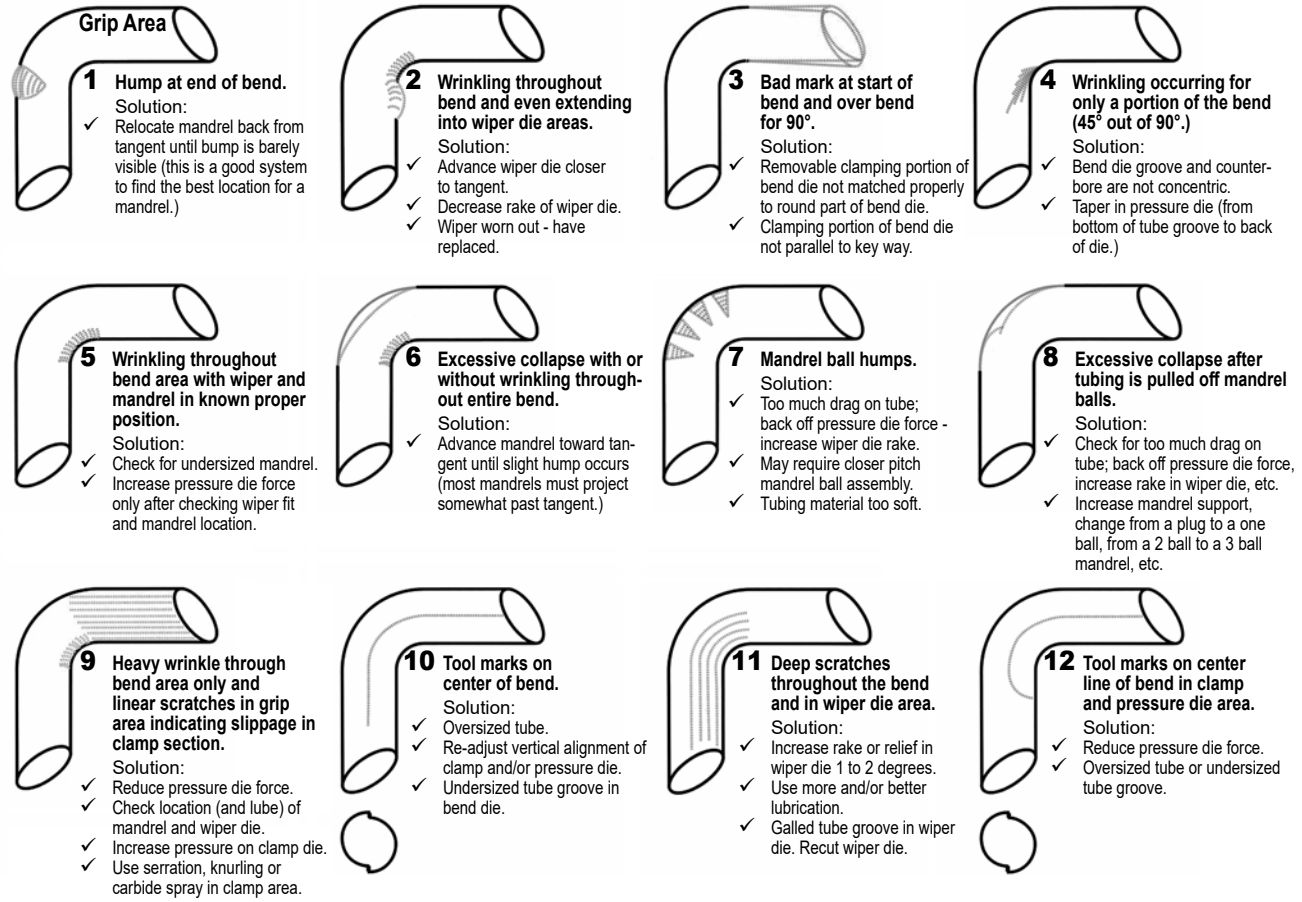
MANDREL BENDING TROUBLE SHOOTING

Problem	Probable Cause	Solution
Hump at the end of outside bend	Mandrel too far forward	Relocate mandrel back
Excessive vibration during bend	Mandrel too far forward	Relocate mandrel back
Mandrel advances, former will not rotate to bend	Mandrel limit switches out of adjustment. Switches are located at the top rear of mandrel table, underneath removable blue cover	Position switches correctly Display should read as follows: Mandrel retracted 100mm Mandrel advanced 0mm Mandrel Between switches 50mm
Mandrel will not retract prior to end of bend cycle (Machine program light is light red)	Need to retract mandrel prior to end of bend cycle	Depress and hold return foot pedal switch for five seconds. Program light should go out and allow mandrel function button to retract manual.
Oval tube	Mandrel too far back	Relocate mandrel back
Wrinkles on inside	Mandrel too far back	Relocate mandrel back
Wrinkles on inside	Mandrel too small	Correct size
Wrinkles on inside	Low pressure die pressure	Increase pressure
Wrinkles on inside	Wrong mandrel end	Adjust to suite material
Wrinkles on inside bend, scratches on tube surface	Low clamping pressure	Increase pressure
Tool marks tube	Oversize tubing	Correct size
Wrinkles on inside of bend with thin wall tubes	Wiper die not positioned well or worn	Adjust or replace wiper die

Common Rotary Draw Mindbenders and their Solutions

When it comes to making a perfect bend, several factors come into play:

- Determine that the bender you will be using is operating properly.
- Make sure clamping and unclamping of dies, rotation of swing arm, and extracting of mandrel are all occurring in the proper sequence.
- Make sure the tube you will be using is clean, both inside and outside.
- Check the tooling, making sure it is clean, burr free and compatible with the tube to be bent.
- Confirm that the mandrel is the required distance past the tangent.



Mandrel Nose Problems:

Ovality (i.e., general deformation of the tube's cross-section) is excessive. Check if the mandrel nose is undersized or not placed deep enough into the bend. If undersized, a temporary fix may be to advance it deeper into the bend. However, optimal bending will require a new mandrel made to the correct nose diameter.

The inside radius buckles. Check if the mandrel nose is placed behind the line of tangency.

The outside radius collapses. Check if the mandrel nose is placed behind the line of tangency.

A hump or humps form on the outside radius. This is usually not because the mandrel nose is too deep into the bend, but because there is excessive drag or insufficient assist from the pressure die. See below for details. However, if you do suspect the mandrel nose is the problem, check the depth of its placement

Drag is excessive. This is not a defect but an immediate cause of many defects. Too much direct pressure die pressure is usually the culprit, however, an oversized mandrel nose can be the problem.

Direct Pressure Problems:

Continuous wrinkling of the inside radius. If the entire arc of the inside radius is wrinkled, this indicates that the direct pressure die pressure is too low. Note that this defect is distinct from a single hump or a small series of humps forming on the inside radius at the end of the bend. This type of wrinkling is associated with the wiper die.

Excessive flattening of the outside radius. A very common problem that results from too much direct pressure die pressure. In effect, the pressure die is clamping on the tube at the point of bend causing the outside radius to stretch and flattening between the pressure die and the clamp die. Reduce the pressure.

If the mandrel nose is properly placed and the direct pressure is correct and flattening is still too much, then the assist pressure should be increased.

Wiper Tip Problems:

A hump or humps form on the inside radius at the end of the bend. The role of the wiper is limited. Humps are the only problem the wiper is designed to solve. Humps only occur if the wiper is not raked correctly or is worn out. Decreasing the rake will eliminate this problem.

Assist Pressure Problems:

Excessive flattening of the outside radius. If excess direct pressure has been eliminated as a source of this defect

A hump or humps on the outside radius. Respond to this in the same way as to excessive flattening if mandrel nose placement is correct.

Excessive wall thinning. If ovality and flattening are under control, then increase the assist pressure.

Other Sources of Problems:

While the set-up is most often the source of a bending problem, other factors may include:

- The machine is not applying pressure consistently.
- The machine is not lubricating the tooling properly.
- The tools are worn out.
- The working surfaces of the tools are mismatched or dimensionally incorrect for the bending application.
- The tubing material is undersized, oversized, or the wrong wall thickness.
- The tubing material is too hard or too soft.

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