H-P Products
Engineered Tube Bends

A Design Engineer's Guide to **Better Tube and Pipe Bend Components**

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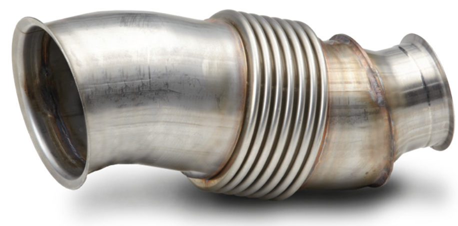
Better Tube Bend Components



FORWARD

This book is about what can be done
There are numerous books and whitepapers to help you become a tube bender. If you want to design better, less costly, parts made from bending tubing, there is little help available. This book hopes to fill the void.

More importantly, this book will help you understand how much you can accomplish with components made of bent steel and aluminum tubing. You may be surprised.

The bending industry has been around as long as we've been able to make metal tubes. It would be a boring world, indeed, if everything followed a perpetual straight line, never bending to follow a better path.

Experienced and engineered-oriented suppliers like H-P Products, can help you create less-costly, better-performing tube bends if you bring them into the process early, preferably at the initial planning stage.

Bending allowed design engineers to replace costly elbow connectors. Now, however, you can do much more to create components that reduce both product and production costs. You can create parts that help your products last longer and operate more efficiently. You can make better use of space, make your parts easier to install and replace, and create bends that stand up to the harshest environments.

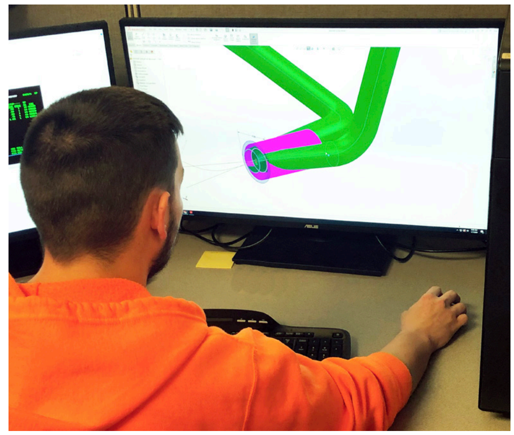
This book will provide an overview of different tube bending processes. It will also help you understand how you can write better component specifications and cut production and installation costs. However, the most important reason to read this book is to improve your component programs using tube and pipe bends. This has been our mission since 1946. Today, with capabilities and knowledge built over six decades, H-P Products, Inc. is more prepared than ever to help you stretch the possibilities of programs using bends.

This book is a start.

INTRODUCTION

If Bending Large Diameter Tube and Pipe Was Easy, Everyone Would Do It
Thin wall tubing over 2" in diameter, is easier to make than it is to bend. The metals used, primarily steel and aluminum, are not known for their ability to stretch and contract at the same time. Wrinkling easily forms along inside bends, where the material compresses, causing weak points and chaotic internal airflow. The resistance of metal fibers to elongation can cause the outer edge to deform at the bend, causing pinch-points where air and materials are compressed into smaller spaces. Connections to other components can become difficult and costly.

This e-book is written for design engineers who don't want their products to suffer from similar problems.



Critical Considerations
This book was written in the belief that the most critical step in any new product design process is to ask the right questions. We will discuss the basic problems inherent in any tube bend process and how to arrive at the most cost-effective solution. We will also present an in-depth look at the basic large diameter tube and pipe bending process to help you see how a more robust solution can be developed for your particular product.

When looking to cut costs, improve performance and speed prototype development, there are four critical factors to consider:

- **Knowledge** – Years ago, we discovered that it takes engineers to understand the needs of other engineers. There are only a select few people in the world, today, who have dedicated their lives to perfecting the art of bending large diameter tubes and pipe.
- **Material** – The speed with which a tube bender can move is greatly determined by the availability of raw stock. The equipment and dies used in tube and pipe bending are a sizeable investment, leaving little room for inventory investments. For this reason, many bending programs, especially in the prototype phase, are hindered by the ability to get the right tube stock.
- **Bend Sets** – The heart of any tube and pipe bending operation. The larger the tooling inventory, the better your chances of finding a fast solution.

REAL WORLD

A manufacturer of forestry equipment was looking for a new tube bending supplier for parts used to connect to a Cummins engine. Not being aware of our extensive industry knowledge, they asked us for a quote. We went a bit further and showed them how a small material specification change, could eliminate the need to yellow di-chromate coat their parts. As a result they were able to reduce production lead times from 20 days to 10.

- **Added Operations** – Extra operations, like welding, end-fittings, custom finishes, etc., add time and cost to any part. Often, there are ways to eliminate many, if not all, of these operations.

Critical Large Diameter Tube and Pipe Bending Applications

The applications where the bending art is most treasured, are those where critical fit, special application needs and the flow of materials, or air, through the tube, are key concerns. Most often these applications have to do with high-volume exhaust and air-movement components, as well as applications where the movement of materials and some liquids are required. In applications where the strength of the tube bend is important it is also critical to maintain the integrity of the tube diameter and smoothness of inner surfaces.

Chapter 1
The Difference Between Pipe and Tube

Tube or Pipe - What's the difference? The two are commonly used interchangeably, however there are a few key differences including how material is ordered and tolerances.

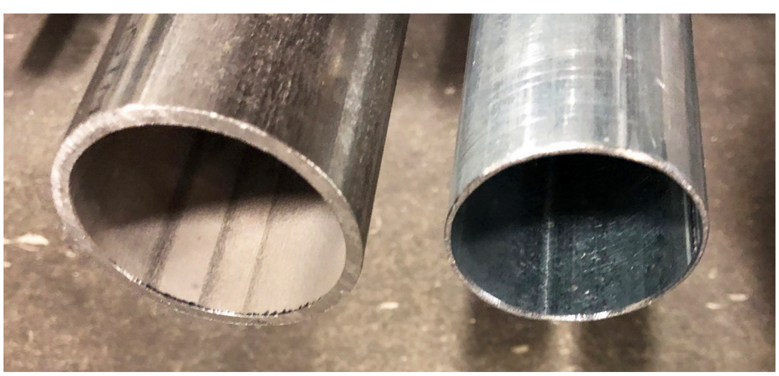
TUBE
Tubing is used in applications that are structural, making the outside diameter (OD) the important dimension. Example of a tube application would be an exhaust as it requires precise outside dimensions. The OD is also important as it indicates how much it can hold as a stability factor. Tube can be round, square and rectangle.

Tubes are generally ordered to outside diameter and wall thickness (either OD and inside diameter (ID) or ID and wall thickness). The strength of the tube depends on wall thickness. The thickness of the tube is defined by a gauge number. Smaller gauge numbers indicate larger outside diameters.

PIPE
Pipes are normally used to transport liquids or gases. Knowing capacity and how much can flow through the pipe is key. The circular shape of the pipe makes it efficient for handling the pressure from the liquid or gas flowing through.

Pipe is ordered using the Nominal Pipe Size (NPS) standard and by a nominal diameter (pipe size) and schedule (wall thickness). The schedule number can be the same on different size pipe, but the actual wall thickness will be different.

Both tube and pipe can cut, bent, flared and fabricated.



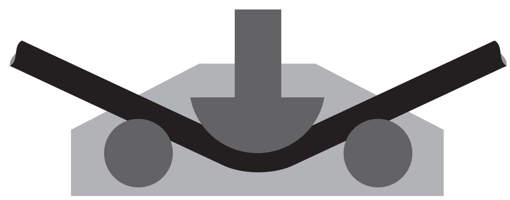
(Pipe shown on the left, tube shown on the right)

Chapter 2
The Anatomy of a Custom Bent Tube or Pipe

Knowing how a bend is made is the first step to understanding what is possible. There are a wide variety of tube and pipe bending processes. Following is a list of the most popular processes and the type of parts they are best used to produce. We will then spend a bit more time exploring those processes best suited to produce quality, precise bends in large diameter thin wall tubing.


Compression Bending

Compression Bending
An economical process most often used to produce parts with shallow radius, where the geometry of the bend is not critical. A piece of tubing or pipe is clamped to a bending die and then hydraulically pressed against the stationary die to create the bend.

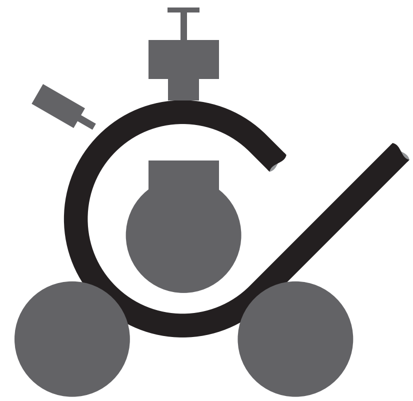

Ram or Press Bending

Ram or Press Bending
The simplest bending process, most often used to bend very large diameter tubes and pipes into a gentle radius or, in the field, to quickly bend smaller diameter pipes. Often used to bend solid pipe or thick-wall pipe and tubing. It is also sometimes used where process speed is a major consideration. Once again, there are restrictions in the tightness of the radius and the geometry of the bend. This process involves clamping a tube or pipe in place and creating a bend by using a hydraulic cylinder to ram a die at the center point. The ends are simultaneously pushed around the ramming die to create the final shape.

Sand Packing
This process is a form of Press Bending, however, dry sand is packed into the tube to maintain interior geometry at the bend. The tube is heated to approximately 2,000°F to improve the ductility of the metal. Dry sand, tightly packed into the area of the tube to be bent, maintains the tube diameter as the bend is formed after removal from the oven. The sand must be completely dry or steam will form with nowhere to escape due to the tube ends being shut to keep the sand in place. With no place for the steam to escape, the results could prove fatal to anyone standing close to the tube. This process is extremely slow, requiring long heat cycles. Bends must be made before the material cools to 1,600°F, so multiple heat and bend cycles are often required, depending on the size of the tube, radius of the bend and wall thickness of the tube.

Infinite Radius Bending

This three-roll process is used to continuously bend tubing or pipe into coils. Two stationary rolls feed the tube as an upper roller is pushed against the tubing or pipe from the other side to create the radius. The material is continuously fed through the three rollers turning straight material into coils of any length.



Infinite Radius Bending

Induction Bending

This process is primarily used to bend larger diameter pipes and tubes, above 8” diameter, although machines are now available to bend tubing as small as 2” in diameter. It is most often used to quickly bend thick-wall tubing or pipe that only requires a single bend. The process, first developed in 1967, heats a narrow piece of the tube by passing it through a circular heat source. The part of the tube passed through the heating element becomes ductile, while the tubing on either side remains non-ductile. Each end of the tube is clamped and, immediately after heating, the bending arm pivots, creating a bend in the ductile portion of the tube. This process is limited to ferrous metals, ruling out aluminum, copper and some copper nickel tubing. It is also not suitable for any thin wall tubing applications requiring a tight radius, where some wrinkling or deformation of the diameter is acceptable.

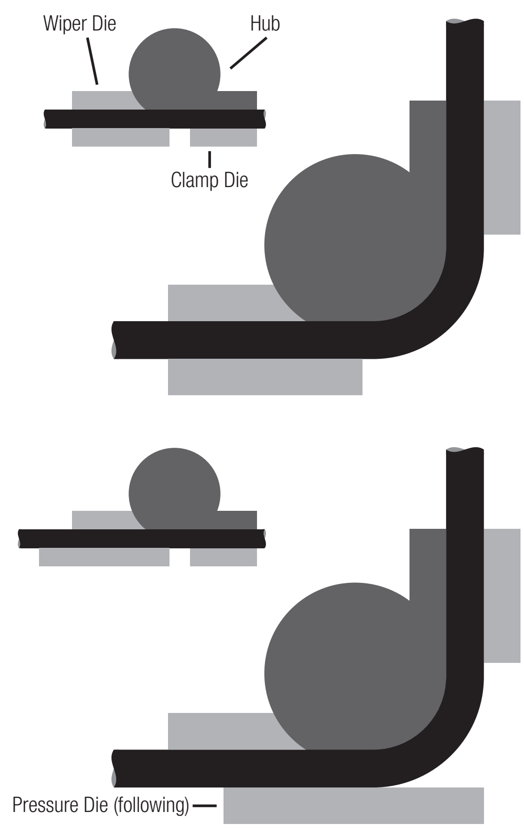
Induction Bending

Internal Roll Bending

The most rare type of bending is used to bend very small quantities of thin wall tubing, mostly above 8” diameter. This process eliminates the need for bending dies as rollers move through the interior diameter, bending the tube as they pass through. Internal Roll Bending is most often used to create odd radius bends where the quantity required does not warrant an investment in new bending dies.

Rotary Draw Bending

This cold-bending method is the most commonly used process when bending larger diameter (above 2”) tubing and pipe, where it is important to maintain the geometry of the bend while accommodating the natural tendency of metals to stretch on the outer side of a bend and compress on the inner side. This process is also used in making complex and tighter radius bends. Bends made using this process are most often found in applications where materials, liquids or air must flow through the tube or pipe without interference from wrinkles or deformation at bends.



Rotary Draw Bending

Rotary Draw Bending machines use a combination of stationary or moving pressure dies that clamp the tube or pipe just beyond the bend area and bend the material over a rotating hub as it moves forward. A mandrel, inserted in the tube or pipe to the bend point, keeps even thin wall material from collapsing when bent. A wiper die follows the material along the interior side (intrados) until meeting the rotating hub. It remains in place to prevent wrinkling where the metal compresses along the interior side of the tube or pipe. Since wiper dies must move along the material surface during the bending process they are formed from softer grade metals, and sometimes plastic. A mandrel inserted inside the tube or pipe, to the mid point of the bend, supports the inner wall to maintain the full diameter of the material through the bend. On thinner wall bends, balls are attached to the tip of the mandrel to maintain diameter in the area immediately before the bend.

Bending Aluminum

This non-ferrous material presents special challenges due to the thinness of the material and its tendency to continue tempering as it ages. The harder the material the more difficult it is to bend, since harder material will have more spring back and even break. In some instances aluminum tubing or pipe must be annealed prior to bending. A good part of the benders art is knowing how to select and prepare the raw stock to handle the bend radius and geometry of the final part.

Aluminum, and all other materials used in bending, will elongate along the outer edge (extrados) of the bend, while compressing and thickening along the inner (intrados) edge. Elongation reaches it's maximum at 90° and will remain constant beyond that point. Skilled tube and pipe benders recognize these stresses and will recommend the right material to accommodate the severity of bend in your application.

Bending Tubes for Pneumatic Conveying

Since these applications often carry abrasive materials, the design engineer should consider a variety of surface treatments along the inner tube wall. Wrinkling along the inner edge of the bend can play havoc with these applications as they disrupt airflow and can also impinge on movement of the product or material.

REAL WORLD

One global truck manufacturer had a Tier One supplier with a problem. A plastic exhaust part they were specifying kept warping. Production had been brought to a halt and they needed solutions fast. We were able to design the same part out of aluminum and deliver ten desperately needed parts in just three days. A full production order soon followed.

Chapter 3
Basic Engineering Considerations

When we look at an application, there are a few basic considerations that tell us how best to proceed. Knowing the application, material, severity of the bends and how the part will attach to other components helps us make value-added recommendations to cut costs, speed production or improve performance. Following are some of the things you should look at to determine if your current tube bends are providing all the value possible.

Application Requirements
The most important consideration often receives the least attention. If you are trying to force a standard tube bend into your design you are likely designing around the component rather than the other way around. Things we look at include:

- The purpose of the component. If it moves air, material or liquid, the formation of the bend will be critical since you will not want the bend to constrict movement or cause unwanted air turbulence.
- The connecting components. Knowing the size and material of connecting components is critical. Different metals react poorly to each other. There may be some flexibility in the size of the required diameter allowing the supplier to use tooling already in stock.
- Available space. A bend may be engineered to more efficiently cover the space from one connection to the next without welding and added operations.

Ductility of the material
The ability of your chosen material to bend under tensile pressure will determine how easy it is to bend with minimal distortion. Ductility is a case of "not too little" and "not too much." It must be "just right."

Too little ductility may not allow the material to bend into the necessary radius. If the material is too hard, it may even break during the bending process. Too much ductility may make it easy to bend, but difficult to hold full diameter throughout the bend, or prevent wrinkling along the compressed inner arc.

REAL WORLD

Over the years, we have often helped customers cut coating costs while improving bend quality by converting from carbon steel to aluminized carbon tubes. This provides a protective surface while eliminating the need to coat parts. The lubricity of aluminized carbon also helps produce a better quality bend.

We have often recommended a different material to customers to create a part more suited to their application, cost and timing issues.

Since heat increases the ductility of all metals, you must also consider how heat generated by your application will affect bends. For this reason, stainless or aluminized carbon steel are the most common selections for tube bends used in exhaust applications. Intake applications are usually best handled by lightweight aluminum components whose ability to reflect heat from the engine make them a superior choice to heat-absorbing plastics and composites.

Radius of the Bend

The next step in matching material to the application is considering the necessary radius of the bend. As we've discussed previously the internal composition of some metals make them better choices for tight radiuses where stretching along the outer (extrados) side will be greater than along the compressed inner (intrados) side.

The radius of a bend is expressed in relation to the diameter of the tube or pipe. 1D bend will have a radius equal to the diameter of the material, so a 1D bend in a 2" OD tube will have a centerline radius (CLR) of 2" (1 x 2"OD). A 3D bend in a 2" OD tube will have a CLR of 6" (3 x 2" OD). In recent years we have seen a growth in demand for tighter radius bends (90° and above). This trend has been compounded by the development of hard-to-bend new alloys.

If the material can tolerate bending to the required radius, a good tube bender will be able to perform a quality bend, without wrinkling where the material contracts, other imperfections due to improper clamping or mandrel placement, or deformations that will hinder efficiency of the application.

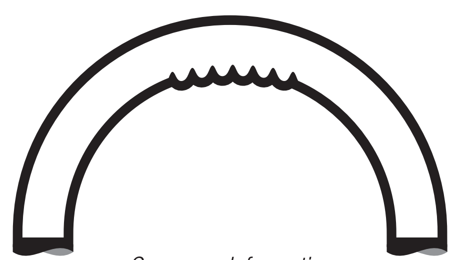
Thickness of the Material

Selecting the right material will lead you to established bending parameters for different diameters and thicknesses of that material. You may choose a certain material thickness based on weight considerations. However, recognize that specifying a material that is not an industry standard can add quite a bit of expense that may not be needed.

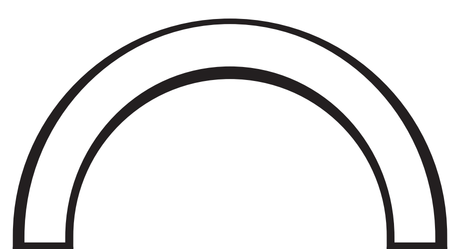
As you would expect, thicker materials require more effort to bend. However, there is the added problem of compression along the inner edge which becomes magnified in thicker materials.

REAL WORLD

Tube bends that will have something flowing through them, can't afford wrinkles at the bend, because it causes restriction or turbulence. These type of applications include transmission of air, refrigerant, hydraulic fluids and similar materials. Tube bends used for structural purposes do not share the functional need for smooth surfaces, but often are preferred for cosmetic purposes.



Common deformation at inner radius.



Compression along inner edge. Thinning along outer edge.

However, the bigger problem is bending thinner wall materials used to save weight and costs in many applications. The thinner the tube wall, the more likely there will be deformations during the bending process. Improper clamping can cause sliding or crimping. Material without enough ductility can break. Improper placement of the inner mandrel can cause deformations along the outer edge, as well.

Geometry

Complex 2-dimensional and 3-dimensional bends along x,y,z axis get any engineer's adrenaline flowing. Development and manufacture of these parts requires precision and operator skill to assure proper fit in the application. **When done properly, sophisticated parts can be made without resorting to welding operations or mechanical connectors to configure tubes with multiple bends.**

Some of the most important considerations are selecting materials with the proper ductility and allowing room for clamping between bends.

Types of common bends

Following are shown the most common types of bends. These are all two-dimensional bends. The Tangent Points are where a bend either starts or ends.

- ***1° to 90° Bends***
- ***91° to 179° Bends***
- ***180° U-Bend***
- ***Single Offset Quarter Bend***
- ***Crossover Bend***
- ***Single Offset U-Bend***
- ***Circle Bend***
- ***Double Offset U-Bend***
- ***Expansion U-Bend***
- ***Double Offset Expansion U-Bend***

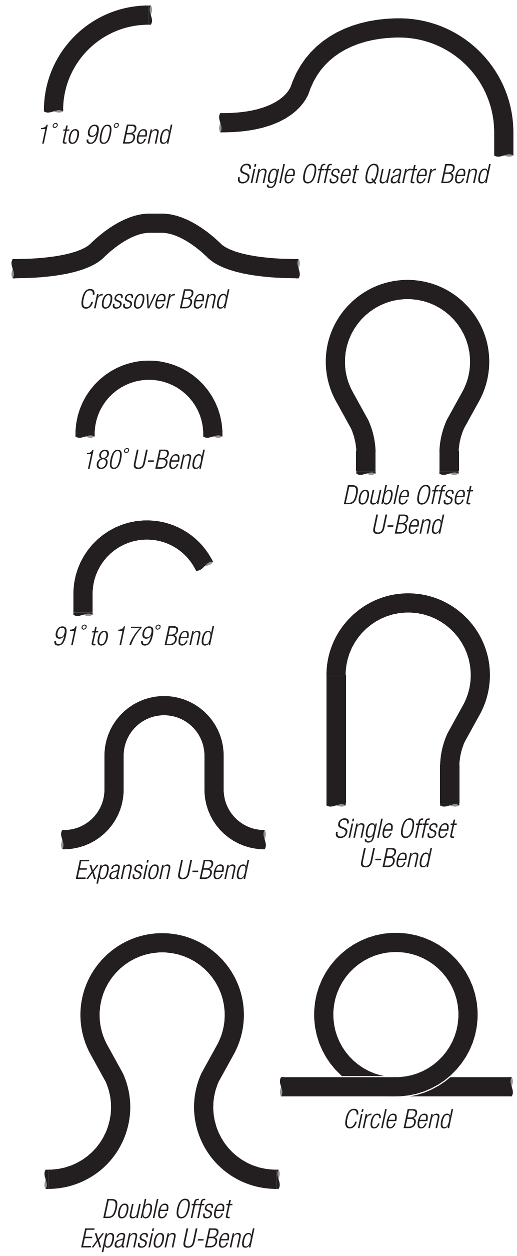
Compound and Compound Multiple-Plane Bends

These are either 2-dimensional or 3-dimensional multiple bends where the limited straight area between the bends is problematic due to secondary operations and scrap.

Special Operations

Skilled tube or pipe benders can perform a number of special operations to cut costs and add special functionality.

Cost cutting operations include those designed to eliminate production steps, both at the bender and in your assembly operations.



REAL WORLD

Talking to a leading diesel engine OEM, we discovered that tighter EPA regulations, to be introduced in 2014, will require total elimination of any potential leak paths in exhaust tubing. This means replacing welded parts with 1-piece compound multiple-plane designs. We are already there.

End Forming

This is an area ripe for money saving operations. If the bender can form a joining end on the part, it will eliminate costly welding and production of separate end parts. At H-P Products, we've turned end-forming into an art and dramatically cut both costs and production time on a number of parts.

Welding

Sometimes, however, a part simply cannot be produced without welding. This is especially true when another component part must be attached to the bends, or the tubes or pipe must be welded together to form a venture. When welding is required, it is important to provide full coverage of the seam to prevent efficiency-robbing air leakage in airflow or material movement applications. Heat from welding operations can also affect the ductility of the material in ways that might adversely affect bending operations.

Insulation

There are two reasons for insulating metal bends. Either you want to protect surrounding components from heat generated by the movement of hot air or gases through the tube or pipe, or you want to protect what's inside from hot ambient temperatures surrounding the tube or pipe. There are a number of insulation solutions for both purposes. The most popular are Alum-A-Fiber Blankets and Applied Wrap Insulation. Applied Wrap solutions are available in a wide range of configurations for custom solutions. Some applications have such demanding heat protection specifications that a combination of both solutions are required.

Heat shields can also be affixed to bends in order to limit the effect of ambient heat on bends and the material inside them.

A key consideration is the time and labor-saving advantages of having insulation wraps applied before tube or pipe bends reach your assembly facility.

REAL WORLD

In order to save time and money, we have often been able to take an existing part and tweak it for a new application. This capability was especially helpful to a manufacturer of large airport snow-blowers. The major components of the design had already been set when we got the call to fill a 2" gap between the tube bends and an adjoining part. We were able to design and produce a solution within one day.

REAL WORLD

One manufacturer of industrial air compressors had a problem with tube bends that were dimensionally out of spec. The parts did not fit when they arrived at the assembly plant, and they leaked air due to poor quality welds. It was not a good situation. We improved weld quality by using Welding Procedure Specifications certified welders and welds. The real innovation, however, was the use of modular fixtures to hold the part from one end point to the other. Fixturing the part in this manner ensured proper fit when delivered to the assembly plant.

Finish
Whether for appearance or long-life, tube and pipe bends can be factory-finished in a number of ways. The most popular include metal treating to add or detract from the ductility of the material. You would add ductility to improve bending quality and subtract ductility after the bending process to improve tube and pipe life.

Stress relieving may also be a requirement. This is typically done to tube ends prior to machining threads.

Other types of finish operations typically done to tube and pipe bends are done to improve cosmetics or resist corrosion in applications where the component will be exposed to moisture or the elements. These include powder coating, e-coating, painting, chrome plating and galvanizing.

Lining
Tubes and pipe can also be ceramic-lined by the bender to resist abrasions during operation and improve service life. The ceramic surface will provide hardness between 8 and 10 on the Moe Scale and can be applied in single or multiple layers, depending on the harshness of the material being transported through the tube. Single coatings generally yield a ceramic surface between 6 and 8 thousands, while a double coat yields a 10-12 thousandths of an inch thick.

Carbon steel is the material most often lined in this fashion. However, we have also provided ceramic linings on stainless steel and aluminum applications.

REAL WORLD

Ceramic-lined tubes offer some outstanding characteristics to applications where rust can not be tolerated. This lining, most often used on carbon steel tube bends, can also be used to improve heat resistance and make the tube bend easier to clean. Ceramic coating can be sprayed on the inner walls of a tube bend, or the entire part can be dipped it the exterior surface must also be coated. The coating is kiln-fired to harden it into final form.

REAL WORLD

Special Operations are often a form of creative problem solving. One Fire Truck manufacturer came to us because they needed to meet a new National Fire Prevention Association (NFPA) regulation. The exhaust from fire trucks was setting dry grass on fire and melting asphalt. To remedy this situation, the NFPA was mandating that exhaust gases had to come out of the exhaust pipe at no more than 851° F. We worked out a way to weld a diffuser to the bent tube exhaust pipe. It worked so well that this design has now become the industry standard.

Chapter 4
Specifying a Large-Diameter Tube or Pipe Bend

Everything we've written to this point points out the key considerations involved in specifying a bend. This chapter will serve as an easy to follow reference guide that you can use on your next project involving large diameter tube or pipe bends.

Step One: Geometry
What is the basic configuration of the part your project will require? Here are the questions to ask yourself and discuss with your tube or pipe bend supplier:

- **Is it a simple, single-bend part, or will multiple bends be required?**
- **If multiple bends are required are they arranged along a single x axis, or will bends align on y and z axis as well?**

- **Must the diameter of the tube remain constant through the bend?** This is largely a function of the material moving through the tube and the effect distortion will have on the efficiency of the transporting process.

Step Two: Material
Here are a few key questions to ask yourself before settling in on the right material for you. Do not take for granted that the material previously specified is the best choice. We have often found ways to cut costs or improve performance using different grades of material, or even different materials entirely.

- **What kind of material, air or liquids will pass through the tube or pipe?** If is abrasive, you will need to select a material that can be lined. If it is heavy you will need to pay close attention to the strength of the material you select.
- **What type of material will the component be connected to at either end?** Some metals affect the corrosion-resistance of others.
- **How severe will be the radius of the bends?** This will largely determine the thickness and grade of materials available to you.
- **Will the component be exposed to moisture or the elements?**

- **Will the material need to be finished in any particular way, either for appearance or functionality?**
- **How important is the weight of the component?**
- **Would it be helpful to reduce the overall weight if at all possible?**
- **How will the component connect to adjoining parts.** If there is an opportunity to fabricate an end as part of the bending process, you might want to select a material that can be easily formed in the manner required.
- **Is the diameter critical to your design, or can you cut prototyping time and costs by specifying a material and diameter already in stock?**

Step Three: Radius
If we know the space available for the component, we can often help you design a part that both cuts production costs and maximizes the efficiency of movement through the part. Here are some basic questions to ask yourself.

- **Does functionality limit your material choices and, in the process, the severity of the bend radius?**
- **What is the center point of any connecting parts?**
- **Will your material choice also force you to allow for "spring-back" after the bends are made?**
- **What is the distance the component must span between connection points?**
- **Are there other impinging parts the component must fit around?**
- **Are there heat sources from which your component must maintain a safe distance?**

Step Four: Length
This is a straightforward consideration. Measuring along center points, you will have to measure two distances.

- What is the total distance between connecting points? This is to help determine if there is another route than can be taken to take advantage of lower cost, stock materials.
- What length of material will be required? To find this dimension, measure along the centerpoint of the tube or pipe, from connection to connection, and through each bend.

Step Five: Special Operations
At this point, you have already determined the configuration of the basic part. It is time to add functionality or cosmetics, as needed. Ask yourself these questions:

- **Must the component, or material passing through the tube, be protected from high ambient heat?** This would dictate the use of an insulating wrapping.
- **Is there a concentrated high heat source located near the component?** This may dictate the incorporation of a heat shield.
- **Does the configuration of the part dictate welding another piece to the tube?**
- **What type of material will be transported in the tube or pipe?**
    - Abrasives may dictate the application of ceramic lining.
    - Liquids may require a sealing wrap.
    - Air movement will require full welds, tight connections and seams.
- Are there cosmetic considerations? These may require the use of paint, powder-coating, chroming or e-coating.
- Will moisture affect the tube? If so, the material may have to be galvanized for protection from corrosion.
- Will ends need to be threaded? This may also require stress relieving operations.
- Will the part require pressure testing?
- Will it be necessary to cut shapes in the material? Laser cutting may be an option, in which case, you will need to pay attention to the thickness of your material. Following are the thicknesses of different materials can generally be laser cut, based on the capabilities of the H-P Products laser cutters.

Aluminum: up to 3/8"
Stainless Steel: up to ½"
Carbon Steel: up to 7/8"
Plate/Sheet: up to 5' x 10'
Tubing: up to 11" OD


Thermal-wrapped bend

Step Six: Connections

How bends connect to adjoining components depends on the material you are using, the vibration expected in the application and the speed with the connection needs to be made. There are any number of options available, including those developed by H-P engineers. The type of connection required will determine the manner of end forming required. Typical end forms include, swaging, flaring, beading, expanding, facing, sizing, Marmon ends, dimpling, punching, coping, threading and Vitaulic grooving. Here are some questions to ask yourself when trying to determine the type of connection best used on your application and, therefore, the type of end forming you will require.

- **Are adjoining components larger in diameter, smaller or exactly the same?**
- **Will the connection need to be permanently welded, or do you want the bent component to be removable and replaceable?**
- **Is the connection easily accessible during installation?**
- **Is connecting speed an important consideration in your assembly operations?**

InstaLok® coupling

Chapter 5

How to Cut Costs Without Cutting Quality

We could make this a very short chapter by simply telling you to get engineers from your bender involved in the design process as soon as possible. However, our purpose in writing this book is to help you ask the right questions and understand that there are more possibilities than you may have imagined.

Here are some key questions to ask as you move through the tube bend development process:

- **Can you use standard tooling and stock?** Costs are much easier to contain if you can eliminate the need for new, custom-manufactured tooling, out-of-inventory stock and secondary operations.
- **How easy will it be to assemble?** The easier it is for a bend to move through the bending operation and final assembly, the more you will be able to cut costs.
- **Are you using the right material?** Beyond using in-stock inventory, there are also a variety of cost-efficient materials and linings you can use to cut costs.

Take advantage of stock die-sets

The cost of producing custom die sets is high. Each set must include clamping dies, mandrels, wiper dies and bending angles, so you might consider how critical is your specified radius. If it can be adjusted slightly, you may be able to take advantage of die-sets your bender already has in stock. If we might digress for a moment to a bit of a sales pitch, H-P Products is noted for the largest stock collection of die sets in the large diameter, thin wall tube bending industry. This inventory has helped any number of customers cut costs.

Engineer easy-to-assemble parts

You probably already have a good idea how expensive every operation is at your plant. By paying close attention to the manner in which your bends will install, you may be able to find significant savings. A good example is the use of Vitaulic ends that securely hold tubular components together without welding or complicated connections.

Use Kits to Simplify Assembly

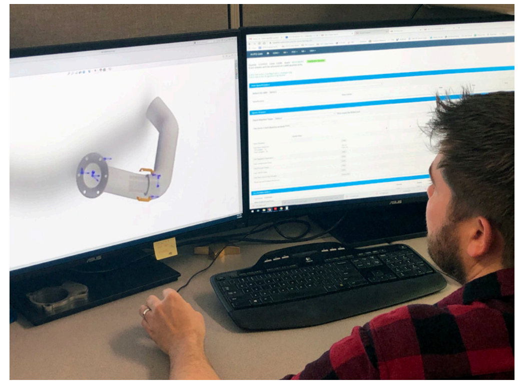
Many manufacturers are now turning to kitting to both simplify and speed their assembly operations. Kits, including the bends, mounting hardware and everything else needed for speedy assembly, are packaged in one box. Kitting makes it easier to inventory everything required for installation, and speeds parts picking, a significant time-waster in most manufacturing operations. If parts are kitted in a manner that makes sense with the installation process, kitting can even speed the installation process.

REAL WORLD

One engine component and sub-assembly manufacturer simplifies and speeds installation by buying tube kits. These kits contain all the necessary parts, clamps and connectors to assemble one unit. Kits are often shipped direct to a job site, or their assembly plant.

Chapter 6
Prototyping Large Diameter Bent Tubes and Pipes

Custom tube and pipe bending is such a specialized art, everything about it screams long lead times and high costs. Dies require quite a bit of time to manufacture and are expensive. Depending on the materials and diameters you need, acquiring raw stock can require more time than most prototyping programs can afford. Often mills require minimum orders far in excess of your prototyping needs.



There is also the matter of engineering support. If your bender doesn't supply robust engineering services, your prototyping process can become one long, costly procession of trials and errors.

All of these problems are compounded if your bender does not have the versatility required for low volume production.

The three keys to a successful prototyping program: Support. Inventory. Versatility.
By working with an engineering-oriented bender you can quickly zero in on your best material and design options. This, in itself, will cut time, frustration and costs from your prototyping process. It will also make it possible for you to smoothly correspond with the vendor to make adjustments throughout the design and prototyping process.

The second step is to **eliminate the need** for custom tooling. Your bender's inventory of stock dies will largely determine your success in this regard. However, you should also pay attention to the amount of stock the bender has in place. You may not need the precise material and size specification your application requires, but, certainly, available stock must be close enough to extrapolate the correctness of your design.

Finally, you need to find a bender who is set up for **short runs**. Prototyping, or initial production runs, never require high-volume production. A bender whose process is designed to run large volumes in a cost-saving manner, seldom has the versatility to efficiently run just a few parts.

Our extensive engineering support, large inventories of die-sets and tube and pipe stock, and the short run versatility of our production process are the reasons other benders often call us in to prototype parts for their customers.

REAL WORLD

Prototyping is never a business for people who like to take their good old time doing anything. One customer had a golden opportunity to manufacture a new military vehicle, but they were only 72 hours from an appointment in Washington D.C., to show a working prototype. Within 48 hours we designed an exhaust component out of aluminum tubing, produced it and had it in their hands the next day. We even helped them pass testing when the time came.

CONCLUSION

There is one final tip we can give you to improve the functionality and cost efficiency of the next tube or pipe bend component you are asked to design. The earlier you bring us in, the more we can help.

We always refer to the kind of bending we do as an art, because skilled practitioners can help you accomplish things you may not have thought possible. It is difficult, if not impossible, to compress six decades worth of tube and pipe bending experience into one book. Rather we've tried to provide the kind of information we've most often seen missing during our work with bending customers around the world.

Today, at H-P Products, Inc., you can talk with engineers, experienced and knowledgeable in the art of bending thin wall, large diameter metal tubes and pipe. You can select from an extensive inventory of die-sets to bend over 2" in diameter, and thousands of feet of thin wall, 2" and larger, tube stock that we always keep in inventory.

Most of all, at H-P Products, you'll find a group of experienced tube bending professionals – engineers and benders, alike – ready, willing and able to help you design a better component.

All you have to do is ask.

About the Authors

H-P Products, Inc. has been a premier manufacturer of tube bends and central vacuum systems since 1945. We have established an internationally-recognized operation to produce high-quality products while servicing the needs of a wide customer base.

After over 65 years of manufacturing success, H-P continues to grow as a result of its diversified product line, flexible fabrication capabilities, ISO 9001:2015 certified manufacturing processes, and quality products and services. H-P is committed to researching and formulating technologies to enhance the product line while pioneering the industry.

Over the years, H-P has become a valued resource for design engineers looking for responsive custom tube and pipe bend suppliers. The company has also invested heavily in three things needed by design engineers with performance-critical, cost-critical and time-critical needs: Knowledge. Tools. Inventory.

SMITHERS
QUALITY ASSESSMENTS

CERTIFICATE OF APPROVAL

This is to Certify that the Quality Management System of:

H-P Products, Inc
2000 West Main Street
Louisville, OH 44241
(Page 1 of 2; see Appendix)

has been assessed and approved by Smithers Quality Assessments, Inc., to the following quality management system standards and requirements:

ISO 9001:2015 with Design

The Quality Management System is Applicable to:

The design and manufacture of piping and tubing related products for the industrial vacuum, pneumatic carrier and pneumatic conveying industries, custom tubular products, and the manufacture of residential built-in vacuum systems and components for the floor care industry.

Approval
Certificate Number: 00.099.2

Original Approval: April 8, 2000

Current Certificate: February 1, 2018

Certificate Expires: January 21, 2021

Q A

The use of the accreditation mark indicates accreditation in respect of those activities covered by the above certificate number.

on behalf of SQA - J. Michael Hochschwender, CEO

The approval is subject to the company maintaining its system to the required standards which will be monitored by Smithers Quality Assessments, Inc., 121 S. Main St., Akron, Ohio 44308, USA

ANAB
ACCREDITED
ISO/IEC 17021
MANAGEMENT SYSTEMS
CERTIFICATION BODY

Form SQA-13.1b.2015 | ISO Multi-Site | Revised: 2/08/19 | (4035-Q-523) – Multi-Site | Current Certificate Revision Date: Current Cert Date 5-19-19

H-P Products Tube and Pipe Capabilities

Material:
Below are H-P's standard, but H-P can get almost any material specified.

Stainless Steel:
- A554 MT304, A269 304/304L, A249/269 Polished OD, A554 MT316L, A554 MT439, A554 MT409

Aluminized Stainless:
- ASTM A554 MT409 A463 COATING

Carbon Steel:
- A513 1006/1008, A787 1006/1008, ASTM 1006/1008 A463

Aluminized Carbon:
- A787

Aluminum:
- B221/241 6061/6063 T4 Extensive list stocked

Manufacturing Processes:
- Bending
- Welding (MIG, TIG, Spot and Robotic MIG)
- Brazing
- End Forming
- Flanging
- Chamfering
- Stamping
- Beading
- Bellow
- Swaging
- Beading
- Expanding
- Facing
- Sizing
- Marmon Ends
- Dimpling
- Punching
- Coping
- Threading
- Victaulic Grooving
- Machining (CNC Vertical machining centers, NC milling machines, CNC Lathe, tooling design fabrication, two 4000W, 6-axis CNC lasers)

Assembly:
- Complex weld tube assemblies - certified to standards of American Welding Association (AWS) and the American Society of Mechanical Engineers

Quality Inspection
- Non contact CMM
- Tube Inspect Vision Scanning system
- Optical comparator
- First article inspections & PPAPs are also performed

Testing Capabilities
- Air pressure decay testing
- Milipore testing
- Burst testing
- Hydrostatic pressure testing
- Salt spray testing
- Hardness testing

Cover:
- Insulators
- Heat Shield
- Fiber Glass Insulation

Surface Treatment:
- Zinc Plating
- Powder coating
- E coating
- Chromium Galvanizing
- Phosphating
- Painting

Other:
- Create fixtures to meet application needs (slot & tab, hard fixtures, Bluco table)
- Barcoding
- Annealing
- Flushing
- Ultrasonic Cleaning

Visit www.H-PCustomFast.com
to see our capabilities in action.

H-P
H-P Products
A High-Performance Company

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02/2020