

Tube Hollows International Engineering Abstracts

Benefits of Concentricity in Tubing

Introduction

Leading design engineers, engineering professors and device manufacturers agree: concentric, seamless precision tubing adds to the reliability, stability, accuracy, and overall life of devices in a range of industries, including the [medical](#), [energy](#), [manufacturing](#) and [automotive](#) fields.

In this white paper, [Tube Hollows International](#) discusses the benefits of concentricity in seamless precision tubing in five industrial applications.



When it's time to turn your engineered design into a reality, choosing the right precision machining partner can mean the difference between a part that falls within acceptable design tolerances or one that holds up production, causing costly delays or even dangerous part failures.

[Tube Hollows International](#) specializes in manufacturing highly concentric tube hollows that meet critical design tolerances. We are dedicated to machining ultra-high concentricity seamless precision tubing in the most challenging alloys, using gun drilling, trepanning, honing and other technologies.

We machine tubing with IDs as small as 0.055" and as large as 5.500". Tube Hollows is able to maintain extremely tight concentricity specs – [Total Indicated Runout](#) of .008" or less along the full length of a tube as long as 25 feet.

Precision and Concentricity

When asked to define precision, a long-time engineering professor at MIT (who is a friend of ours) commented, “Precision is the place where other people give up.”



Expanding on that definition as it relates to seamless precision tubing, David Morse, General Manager at Tube Hollows International says, “What was considered precision machining fifty years ago is probably no longer precision machining today. Now you’ve got to do something different. This evolution means pushing to get to the next level. Precision machining takes place when you solve a problem everyone else has given up on. The field is in constant evolution.”

Morse acknowledges many of [Tube Hollows International](#)’s customers have been turned away by other machine and metal working shops after being told their design tolerances are “too demanding.” In other instances, customers have turned to Tube Hollows when other machine shops have failed to meet the minimum design and concentricity specifications.

The Importance of Concentricity in Tubing

Tube Hollows International works hard to meet customers' exacting specifications because we understand the importance of [concentricity](#) in seamless precision tubing. As defined by GD&T, "Concentricity, sometimes called coaxiality, is a tolerance that controls the central axis of the referenced feature, to a [datum axis](#). The axes for the datum and referenced feature are derived from the median points of the part or feature. Concentricity is a very complex feature because it relies on measurements from a derived axis as opposed to a tangible surface or feature."

Concentricity isn't a buzzword or sales slogan: it is a design imperative.



According to leading engineering professionals, concentricity in seamless

precision tubing:

- Increases efficiency (use of material, flow rates, etc.)
- Helps parts wear evenly and predictably
- Minimizes vibrations in rapidly rotating parts
- Handles high pressures consistently and effectively
- Yields higher quality and superior productivity for tube drawing processes that begin with a starting hollow
- Helps ensure a tight fit between tubing and other fixtures

[Determining the concentricity needs](#) of your project hinges on many factors, including:

- How your part will function in its end use
- Whether or not the part will interact with other parts
- Environmental factors influencing tolerances for the part

Every engineering project calls for a balance between design specifications, cost, safety, and quality concerns. In the early stages of research and design, it is important to determine concentricity standards, and then ensure your seamless precision tubing is manufactured and machined within those strict guidelines.

The following examples in this white paper illustrate how concentric, seamless precision tubing solves critical design challenges across a wide range of [industries](#), including the [medical](#), automotive, [energy](#) and [manufacturing](#) sectors.

Concentricity and HPLC System Tubing

Industry Background:

HPLC ([high performance liquid chromatography](#)) is one of the most versatile analysis tools in the modern laboratory. The process relies on pumps, which pass a liquid solvent containing the sample mixture through a column filled with an absorbent material. Each component in the sample interacts with the absorbent material, causing different flow rates for each component. Ultimately, the component parts are separated as they flow out of the column.



HPLC is used in many industries, including: medical (to test blood serum levels); legal (testing for the presence of illegal drugs); manufacturing

(production of biological and pharmaceutical products); and research (separating synthetic chemicals, testing biological samples).

HPLC: Development and Benefits of Concentricity in Tubing

Since its discovery in 1952, HPLC technology has advanced, giving researchers greater accuracy and new ways to test sample materials. Although modern HPLC techniques can separate smaller particles and test solutions with far greater accuracy, chromatographers still face some of the same challenges using HPLC as they did in the early days, including band broadening, poor resolution and undesirable peak shape. With the advent of ultra-advanced chromatographic techniques, including UHPLC, challenges experienced by technicians have only increased.

An objective review of HPLC technology shows that chromatographers often blame common problems on the wrong components of the system. Poorly packed columns and mobile phase composition frequently prevent accurate and consistent results, but they are by no means the only culprits. High quality alloy columns play a critical role in HPLC performance and many scientists underestimate the role [concentric seamless precision tubing](#) can play with respect to flow path, accuracy and reliability.

To understand the importance of concentric seamless tubing in HPLC, technicians must take a wide-angle view, going all the way back to the design and manufacture of the machines they rely on to test samples.

When the [wrong tubing is chosen](#) in the design of HPLC machines, the fluid cannot pass through the tubing easily during testing, and this hampers the overall effectiveness of HPLC. For example, if the tubing is incompatible with the biological sample being tested, particles can stick to the walls of the tubing, ultimately causing low sample yield, carry over, and other problematic results.

Concentric seamless precision tubes allow sample particles to flow freely, and can also be manufactured from specialty metals which don't interact with the particles being tested.

The choice of concentric seamless precision tubing is also important in today's modern HPLC systems, which rely on variable, [high-pressure pumps](#). In order to yield a consistent and reproducible flow rate, the tubing in these high pressure pumps must reliably work at up to 100 MPa (15,000 lbf/in²), or about 1000 atmospheres. This can only be achieved with highly concentric tubing because it performs well against extreme pressure requirements and it handles thermal expansion evenly and does not preclude particle flow.

Complicating matters further, fitting sizes can vary, making highly precise tubing an absolute necessity. The outer diameter of the tubing leading from the reservoir to the pump may be one-eighth of an inch, but in many systems, changes to one-sixteenth of an inch after the pump. In other systems, the outer diameter changes to one-thirty second of an inch.

In order to secure an [accurate and reliable fluid](#) pathway, seamless precision tubes must be manufactured with [properly concentric/variable ODs](#), and extreme attention to concentricity.

Lack of concentricity in seamless tubing is the culprit in many problematic HPLC machines, but few scientists understand the importance of the tubing and instead focus on other aspects of the process. But when seamless precision tubing is correctly chosen for the HPLC application (taking into account the sample's biocompatibility, concentricity requirements, ability to withstand variable temperatures, pressures and flow rates, etc.) it helps HPLC systems to function optimally.

Conclusion: High quality finish, perfectly concentric seamless tubing allows HPLC processes to work efficiently, helping to prevent biological agents from snagging on tubing walls. Pumps manufactured with concentric seamless tubing operate efficiently under the high stress, high pressure environments of ultra-high precision HPLC because they are designed to handle variable/high pressures, temperatures and continue to operate optimally when non-concentric seamless tubing would fail.

Medical Device Industry

Medical device manufacturers face stringent product quality and process capability requirements. Seamless drawn tubing and wire is used widely in the manufacture of pacemakers, stents, and other high-tech medical devices. Seamless drilled tubing is often the foundational component in trocars and medical implants such as bone nails. All of these products must necessarily be:

- Free from surface imperfections and solvents
- Biocompatible, sometimes biodegradable
- Able to withstand variable temperatures and pressures
- Able to withstand very high and low temperatures
- Corrosion resistant
- Uniformly strong and resistant to fatigue

The common key starting point for all of the above-mentioned devices is a precisely machined, tight concentricity starting hollow. For example, the current state of the art concentricity spec for a 6-foot long starting hollow with an OD of 0.500" and a 0.312" ID would be a "TIR not to exceed 0.004"." Only super concentric starting hollows machined to this level of precision feature the necessary wall uniformity to permit metal to be drawn down into hollow, pacemaker wire 0.001" in diameter. Similarly, metal stents made from nitinol or L605 can only be efficiently manufactured when uniform wall input hollows are carefully drawn into thin walled tubing and then laser cut. For this reason, many of the most precise, advanced medical procedures and developments of the twenty-first century have been facilitated by the dependability of [gun drilled](#), concentric seamless precision tubing.



Modern, minimally invasive surgical procedures rely on ultra-thin, flexible, seamless tubes that are sometimes as thin as a human hair. This medical-grade seamless tubing allows doctors to perform endoscopes, ablations and other procedures with the help of tiny, micro-filament cameras fed through perfectly smooth, concentric tubes, cannulas and ultra-fine needles.

The [seamless tubing](#) used in these cutting-edge medical procedures helps eliminate snags and complications during intricate surgical procedures. The smooth finished, concentric interior of a seamless precision tube allows even, predictable tissue and debris removal, reducing the likelihood of clogs, device failures, and the need to change out devices during surgical procedures. Concentric seamless tubes also allow medical professionals to precisely inject fluids and medications with unimpeded, predictable flow. Even the smallest variation in wall thickness or diameter can hamper aspiration, surgical exploration or imaging procedures.

Other medical devices such as bone nails, trocars and other long, cannulated components may require custom drilled tubing or cannulated bar to achieve the specific performance desired. Typically, this type of a machining solution is required when a design requires exceptional strength and wall uniformity but in a size or an alloy that does not lend itself well to standard tube drawing processes.

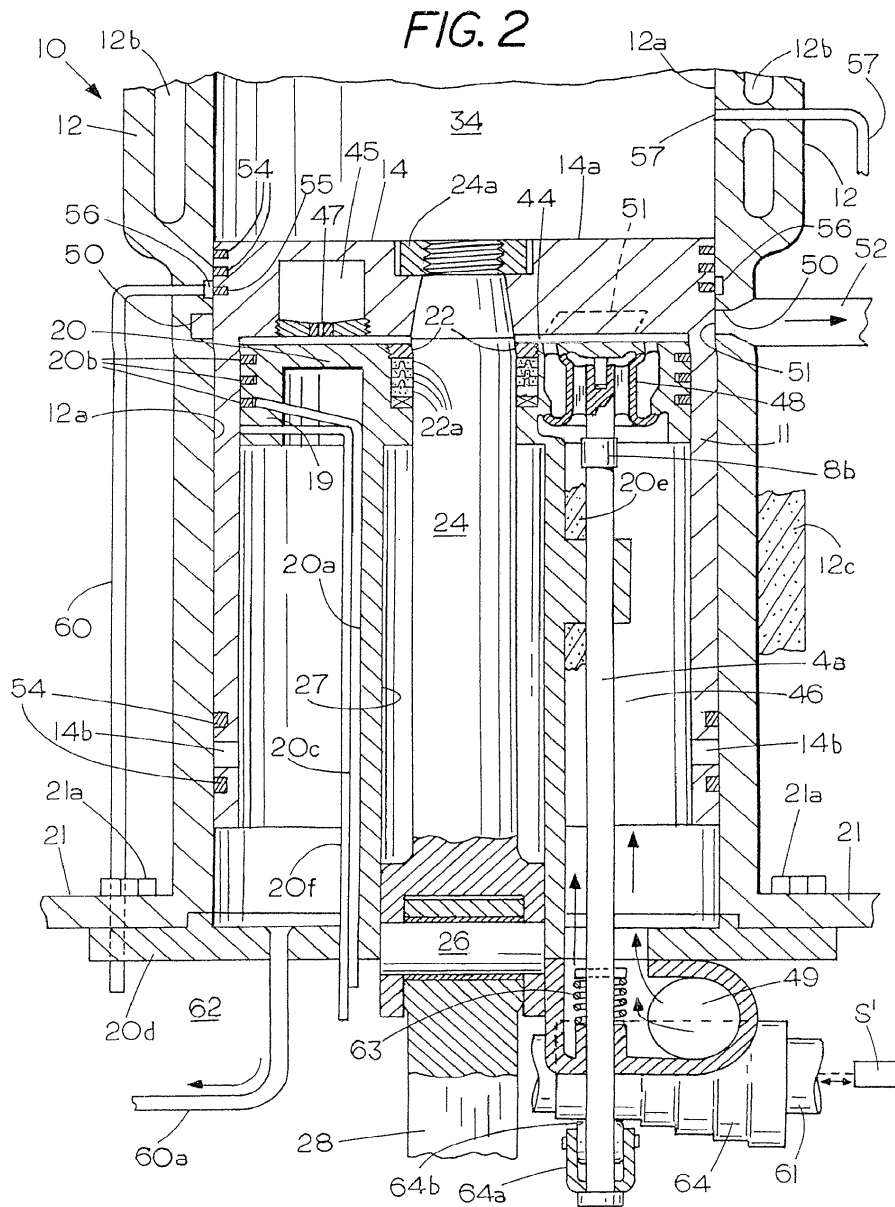
A sophisticated, [highly specialized](#) machining shop is critical when working

with the strict tolerances of medical device manufacturers. Tube Hollows International was one of the early pioneers of drilling [nitinol](#), a material often used in cardiac and peripheral stents as well as other medical devices. Tube Hollows International often works with medical device designers to produce custom cannulated bar and custom tubing for trocars, stents, trauma nails and other medical applications which demand tight tolerances and stringent quality control.

Conclusion: Medical device manufacturers rely on [gun drilled](#) seamless precision tubing and starting hollows as a fundamental starting point in their supply chain. Tight concentricity starting hollows ensure that drawing processes can deliver precision tubing that features superb wall uniformity and surface finish, as required by demanding surgical and medical applications.

Energy Production and Process: Boiler Design

Precision seamless tubes used in boilers operate at high temperatures in corrosive environments. In order to increase plant efficiency and reduce harmful emissions, power plant operators often rely on [gun drilled](#), concentric seamless precision tubing for reliable gas flow and particle capture.



Seamless precision tubing used in power generation must be concentric, because any variation in [ID/OD](#) can cause uneven flow of gas, steam, or buildup of emission particles in an area of non-concentricity. An irregularity in a power plant's seamless precision tubing can ultimately cause dangerous, even deadly, fluctuations in pressure, vibration, and temperature.

Seamless tubing [used in boiler applications](#) must have:

- High creep resistance
- Oxidation resistance
- Corrosion resistance
- Structural stability
- Ability to withstand variable pressure
- Ability to withstand high temperatures

The seamless precision tubing found in a power plant's boiler is [critical to the plant's efficiency](#). Boiler efficiency increases by 1% for every 40 degree F (22 degree C) drop in exit temperature, so efforts to reduce temperatures are vital to safe and cost efficient plant operation.

Design engineers rely on seamless, highly concentric, gun drilled seamless tubing in boiler applications because concentricity allows for:

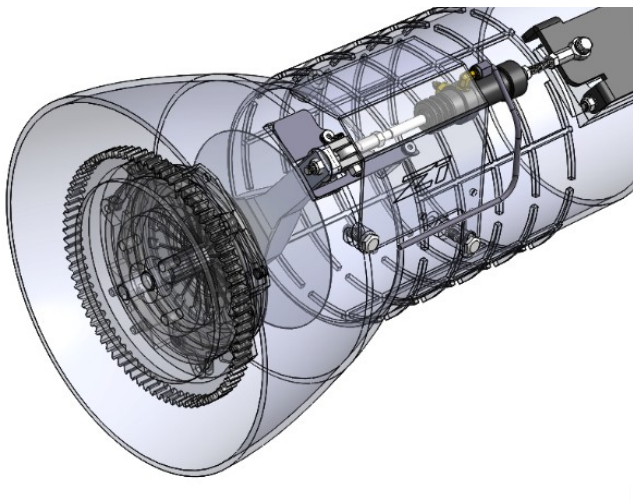
- Efficient, unimpeded flow of steam/gas
- Tighter fit when coupling parts (i.e. gills)
- More effective removal of soot (does not collect in narrowed portion of tubes)
- More efficient arrangement of tubing (tube banks can be deeper at 2m, allowing gas exit temperature to be lower)
- Unimpeded flow reduces likelihood of vibrations in tube
- Unimpeded flow reduces likelihood of tube failure at non-concentric point
- Even thermal and relative expansion of concentric tubes reduces vibrations and risk of catastrophic failure

Conclusion: Concentric, gun drilled seamless precision tubing is often used in [the power generation industry](#). It resists corrosion and thermal fatigue, handles extreme pressures and temperatures, wears evenly and allows for tighter fits between critical parts (i.e. safety valves, joints, etc.) Non-concentric seamless tubes can cause critical failures in power plants, such as build up of debris (soot), uneven expansion and contraction, and loose fittings.

Automotive Applications

Concentric, precision seamless tube hollows are used in many automotive applications. Automotive engineers rely on [seamless precision tubing](#) to drive the industry forward, using its concentricity, homogenous structure and other advantageous features to design cars with:

- Increased fuel efficiency
- Reduced vibrations
- Lighter weight components (steering columns, suspension systems, instrument panels, etc.)
- Crash reduction systems (i.e. passenger airbags: seamless tubes must withstand pressure load of 700 bar, 300 degree C fluid flow without vapor bubbles)



The homogenous, concentric structure of precision seamless tubing also

produces automotive parts with excellent fatigue strength. Concentric starting hollows, as they are drawn into automotive parts, also have exceptionally smooth surface finishes.

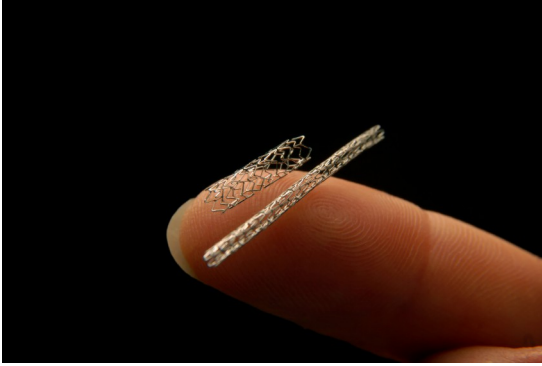
For safe and optimal engine operation, gas and other fluids must flow unimpeded through internal tubing. These flow rates can be quite high, and significant vibrations can be caused if the flow is interrupted by an irregularity in the internal diameter of a tube. Vibrational forces can impede proper function of the engine, or cause catastrophic part failure.

Concentric seamless precision tubing is also the material of choice for modern exhaust systems. In addition to unimpeded airflow, [exhaust silencers](#) are prone to corrosion internally and externally. If there are variations in concentricity inside the tube, the exhaust system will wear unevenly. This can lead to vibrations or premature part failure (stress fatigue, leakage, etc.) The tight concentricity of seamless precision tubing also makes achieving a tight fit between engine components and car parts easier, stopping leakage and preventing air intake, which adversely affects catalytic conversion.

Conclusion: Concentric seamless tubing allows automotive design engineers to produce lighter weight, safer, more fuel-efficient vehicles. Concentric tubing is used internally (engine, safety systems, electronics) and in other critical support and control structures (steering columns, brakes, fuel lines, exhaust systems, etc.)

Unique Precision Manufacturing Applications

Tube Hollows International's ability to supply our customers with concentric, gun drilled starting hollows in a wide variety of eccentric alloys allows us to partner with design engineers in a wide variety of industries. Concentric seamless precision tubing solves critical design challenges for medical device manufacturers, makes automobiles safer and more fuel efficient and increases the safety and efficacy of power generation facilities.



Many Tube Hollows customers bring projects to us that other manufacturing and metal working shops have mishandled. At Tube Hollows, we thrive on solving the [most difficult design challenges](#), and continuously leading the industry in gun drilling and precision machining innovation.

Every customer we've had the pleasure of working with comes to us with unique design challenges, particular part specifications and their own nuanced story. Recently, a respected, avant-garde musical instrument manufacturer came to us asking for help with a high precision titanium shaft for a unique guitar design. The customer's current supplier was struggling to produce the necessary precision. Tube Hollows has the confidence and the experience to deliver challenging parts where other machining companies come up short.

When we see and hear about the end uses of our concentric tubes, whether in the award-winning design of a guitar, the roar of a jet engine, or the healthy functioning of a human heart, we at [Tube Hollows International](#) know our dedication, commitment and desire to provide the best seamless precision tubing in the industry is more than worth the effort.