Swagelok Western New York

WHITE PAPER

The Case for Tubing Versus Pipe in Modern Fluid Systems

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Why forward-thinking engineers are moving beyond threaded pipe

Executive Summary

Fluid system design decisions have long-lasting consequences for safety, operational efficiency, and total cost of ownership. For decades, threaded pipe has been the default choice for process lines, instrumentation runs, and mechanical seal flush systems. However, engineering evidence and field experience consistently demonstrate that tubing systems deliver measurable advantages in the majority of small-bore applications (fluid systems with an outer diameter of 2” or less), fewer leak points, lower installation labor, easier maintenance, and better overall system integrity. This white paper examines those advantages across four dimensions: physical characteristics, leak potential, installation efficiency, and total cost of ownership.

Tubing vs. Pipe: The Fundamentals

The two types differ in specification, manufacture, and handling in ways that matter throughout the system lifecycle.

Pipe is specified by Nominal Pipe Size (NPS) and pipe schedule. NPS specifies the pipe’s diameter with the difference being it is a reference number rather than an actual measured dimension. Pipe schedule references wall thickness and is also a non-dimensional number. Both numbers are used to determine a pipe’s wall thickness. Pipe is hot-rolled and rigid; shaping it requires special equipment, and each end must be threaded before it can accept a fitting.

Tubing is specified by the measured outside diameter (OD) and wall thickness. Tubing can be hot- or cold-rolled. It can be bent to route around obstructions without additional fittings, and cut ends require only deburring and facing before installation.

Pipe	Tubing
Specified by nominal size and pipe schedule (not actual dimensions)	Specified by actual OD and wall thickness
Hot rolled only; rigid	Cold or hot rolled; bendable and coilable
Requires thread cutting at each end	Requires only deburring and facing
Heavier; extra material consumed by threads	Lighter; no thread material waste

Leak Potential and Connection Integrity

Threaded pipe connections are the primary source of leak risk in small-bore fluid systems. NPT fittings depend on interference fit supplemented by a thread sealant, typically PTFE tape or anaerobic liquid compound. This approach introduces compounding vulnerabilities: sealant application is operator-dependent; "wrench tight" varies with the installer's strength; elbows are frequently over- or under-tightened to achieve alignment, damaging threads and creating leak paths. Once assembled, removing any single component requires sequential disassembly of every downstream element, and each reassembly reintroduces leak risk.

Tubing eliminates most of these vulnerabilities through two mechanisms. First, compression tube fittings create a metal-to-metal ferrule seal under controlled advancement, no sealant, no thread condition dependency, no subjectivity. The fitting geometry is gaugeable after initial pull-up, providing visual installation verification. Second, tubing's bendability reduces the number of elbows and couplings used to create connection points and potential leak points. Bends also produce lower turbulence and pressure drop than pipe elbows, improving system flow efficiency.

Installation Efficiency and Labor Cost

Pipe's lower material cost is the primary reason it continues to be specified, but *total installed cost* tells a different story. Threaded pipe requires cutting, deburring, threading, sealant application, assembly, torquing, and leak testing at every joint, plus frequent rework for misaligned elbows. Welded systems add permits, fire watch, and weld tent requirements.

Tubing installation reduces this to four steps: cut, deburr, bend, and install fittings. No threading equipment, no sealant, no sequential assembly constraints. A single installer can complete a tubing run in a fraction of the time required for an equivalent pipe circuit. In vibration-intensive environments, commonly found near pumps and compressors, tubing can be routed close to the equipment body, reducing unsupported spans and vibration-induced fatigue. Tube fittings are designed to maintain mechanical integrity under vibration, providing an additional reliability advantage over threaded connections.

Maintenance and Total Cost of Ownership

The serviceability advantage of tubing becomes especially apparent over the operating life of a system. Maintenance on a tubing system is straightforward: loosen the nuts at each end of the affected run, remove the tube, perform the work, and reinstall. No sequential disassembly, no sealant residue, no thread inspection. By contrast, accessing a failed joint in a threaded pipe system may require disassembling multiple upstream components, each step reintroducing leak potential. Welded pipe systems are the least forgiving: adding an instrument tap or clearing a clog may require cutting out and replacing an entire spool piece, with full permit and fire-watch requirements.

Summary: Why Tubing Outperforms Pipe

Fewer connections → fewer potential leak points
Bendable routing → simpler runs with fewer fittings
Gaugeable fittings → verifiable, consistent assembly
No sealants or threading → faster installation, less rework
Easy disassembly → lower maintenance labor and downtime
Lower total installed cost → labor savings exceed material premium

Conclusion and Recommendations

In small-bore fluid system applications, tubing outperforms threaded pipe on every measure that matters: leak integrity, installation speed, maintainability, and total cost of ownership. The perception that pipe is the lower-cost option holds only for raw material price; once labor, connection count, and lifecycle maintenance are factored in, tubing systems consistently deliver lower total costs.

For engineering teams evaluating fluid system design:

- Default to tubing for small-bore instrumentation, process sampling, and mechanical seal support systems.
- Perform a connection-count audit on existing pipe systems to identify high-leak-risk areas for tubing conversion.
- Compare total installed cost versus material cost alone, when selecting between pipe & tubing.
- Invest in tube bending and fitting installation training to fully realize efficiency gains.
- Engage a fluid system specialist to advise on product specification for your particular application.

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