Swagelok Western New York

WHITE PAPER | INDUSTRIAL FLUID SYSTEMS

The Hidden Costs of Leakage

What a Leak Really Costs Your Plant

Executive Summary

A single tube fitting leaking at one drop per second wastes over 400 gallons of fluid per month. Scaled across a typical process plant, uncontrolled leakage, whether liquid or gas, is one of the most pervasive, and underestimated, cost centers in industrial operations. Grounded in the Swagelok Tube Fitter's Manual, this white paper looks at seven forms of leakage loss and provides a five-step plan for prevention.

Key Finding

Industry data shows 60% to 80% of tube fitting leaks stem from improper installation — not defective hardware. The Swagelok Tube Fitter's Manual addresses this directly with standardized, repeatable assembly procedures.*

How Leaks Happen

Genuine Swagelok tube fittings work through controlled ferrule advancement which mechanically grips the tubing outer diameter (OD) while creating a robust seal against the fitting body. When properly installed, Swagelok's two-ferrule, compression-grip tube fittings produce a repeatable, leak-tight seal (an average leak rate of 1.53% vs. 14.32% for other manufacturers' tube fittings), even after being reassembled multiple times.

However, when tube fittings are improperly installed due to under-tightening, over-tightening, misalignment, incompatible tubing hardness, or insufficient tube insertion depth, the seal does not form correctly causing it to leak immediately or degrade under thermal cycling and vibration.

The Seven Leakage Cost Categories

1. Direct Product Loss

It is estimated that millions of gallons of hydraulic oil are lost each year just through leakage. At just one drop per second, a single leak costs $4,160/year at $10/gallon — and most plants have dozens of leaks.

2. Equipment Damage

The loss of fluid lubrication can lead to costly equipment damage such as premature wear and machine failure.

3. Safety Incidents

Fluid leaks can be responsible for numerous plant incidents, including slip-and-fall hazards ($38 000 to $74 000 per OSHA recordable), chemical burns ($150 000 to $500 000 per lost-time incident), and fire/explosion risk ($1M to $100M+ per event).

4. Unplanned Downtime

Production output is greatly reduced every time a plant shuts down a process to fix a leak resulting in significant profit loss.

5. Energy Penalty

Power is used to pressurize hydraulic systems and to compress air. According to the US DOE, compressed air systems alone lose 20% to 30% of output to leakage resulting in thousands of dollars of wasted electricity per leak.

6. Regulatory and Environmental Liability

EPA 40 CFR Parts 60 and 63 mandate Leak Detection and Repair (LDAR) monitoring of connectors, including tube fittings, in volatile organic compound (VOC) and hazardous air pollutant (HAP) service. Violations carry steep consequences:

- Unreported leaks: $25 000 to $100 000 per violation
- Consent decrees for systemic failures: $1M to $30M+ in fines plus mandatory capital rebuild
- Exceeding maximum fugitive emissions: up to $37 500/day per violation

7. Product Contamination

Leaks can cause improperly calibrated or operating instruments which can result in off-specification product. In the food, beverage and pharmaceutical industries, plants cannot risk contaminated products due to leaks. In both cases the result can be millions lost in discarded product.

Prevention: The Swagelok Five-Step Framework

The Tube Fitter's Manual explains correct assembly in five verifiable steps that eliminate the majority of installation-induced leaks at near-zero incremental cost:

- **Step 1 — Tube Preparation:** Cut square, deburr the OD and inner diameter (ID), and verify dimensional tolerances.
- **Step 2 — Full Insertion:** Push tubing fully to the tube stop before tightening.
- **Step 3 — Finger-Tight Reference:** Finger-tighten until resistance is felt. This establishes the baseline for prescribed make-up rotation.
- **Step 4 — Prescribed Make-up:** Apply the specified turns from finger-tight (typically 1 1/4 turns) using a backup wrench. Over-tightening collapses the seal geometry and accelerates fatigue cracking; under-tightening results in an improper initial seal being made which can cause leakage or a potential tubing blowout.
- **Step 5 — Leak Test:** Determine the appropriate leak detection method: Visual, Bubble, Pressure Change, Airborne Ultrasonic, or Mass Spectrometry. Document by connection ID, date, and technician for LDAR compliance, as per EPA 40 CFR Parts 60 and 63.

Importance of Training

With the vast majority of tube fitting leaks caused by improper installation, the value of proper training cannot be overstated. Correct tube fitting installation is essential for productive and safe system operation.

A training program such as Swagelok's Tube Fitting Installation Essentials, will provide all technicians with foundational tube fitting knowledge that will maximize safety and minimize the risk of leakage while ensuring their system's integrity.

Recommended Actions

- Commission a baseline leak survey (ultrasonic or bubble solution)
- Adopt the five-step procedure as a plant standard
- Train all technicians making tube connections; document records per OSHA Process Safety Management (PSM) requirements
- Mandate post-make-up leak testing before returning to service
- Schedule annual leak detection audits; track repeat calls as a KPI

For over two decades Swagelok Western New York's fluid system specialists and field engineers have been working with customers in diverse industries to develop and implement leak detection programs. This collaborative effort takes place onsite at a customer's facility to help them identify risk factors, solve pressing challenges, and optimize their fluid systems.

Swagelok Western NY's typical leak detection service includes:

- Our field engineers performing a leak detection evaluation on a plant's gas and/or fluid systems
- A detailed report identifying leaks, determining root causes and highlighting design issues
- Prioritized improvements that maximize the return on the maintenance budget
- Field engineers work with plant personnel to create new design standards for systems
- Fluid system specialists conduct training for personnel on proper component installation

Conclusion

The Swagelok Tube Fitter's Manual is, at its core, a document about the economics of reliability. A drip is not a minor inconvenience — it is a compounding liability spanning lost product, wasted energy, regulatory exposure, safety risk, and maintenance burden. Facilities that treat tube fitting integrity as a precision craft, supported by standardized procedures, proper tooling, and systematic verification, give themselves the best opportunity to outperform peers on safety metrics, compliance records, and plant profitability.

**References: Swagelok Tube Fitter's Manual (MS-13-E) · EPA 40 CFR Parts 60 and 63 · U.S. DOE Compressed Air Challenge · API RP 754 · U.S. CSB Incident Reports · OSHA 29 CFR 1910.119*

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