HOW COMPRESSION FITTINGS CAN MAKE OR BREAK A COMPRESSED AIR SYSTEM

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From eliminating incorrect installation to minimizing leaks and corrosion, a system's success depends on reliable connections.

Introduction

In process, motion control and instrumentation applications in industrial settings, fluid delivery systems that are powered by compressed air require secure, leak-proof joints capable of withstanding high pressure, vacuum and vibration situations. Without a secure connection, these joints become the weak points of any system and can create a multitude of costly problems.

In an industrial energy efficiency sourcebook titled Improving Compressed Air System Performance, the U.S. Department of Energy states that leaks can be a significant source of wasted energy in an industrial compressed air system. In some cases, leaks can waste 20 to 30 percent of a compressor's output.

In addition to being a source of wasted energy, leaks can also contribute to other operating losses:

- Leaks cause a drop in system pressure, which can make air tools function less efficiently, adversely affecting production.
- By forcing the equipment to run longer, leaks shorten the life of almost all system components and can lead to additional maintenance requirements or increased unscheduled downtime.
- Leaks create a significant safety hazard for plant personnel, especially if the fluid delivery system is handling acids, solvents and other caustic chemicals.

While leakage can come from any part of the system, the USDE sourcebook identifies couplings, hoses, tubing and compression fittings as the most common problem areas. The annual cost of wasted energy can range from $523 for a 1/16" leak to $8,382 for a 1/4" leak; multiply those figures by the number of couplings in a system, then by the number of systems in operation, and the losses increase quickly and substantially.

Another concern is corrosion to system components, which for many industries can represent the difference between trouble-free operation and costly downtime. In a recent Compression Fittings, Materials and Tubing Guide published by Parker, a global leader in motion and control technologies, the company states that the cost of corrosion accounts for a total of $276 billion in operating losses per year, according to a report conducted in the USA. The production and manufacturing sector accounts for 12.8 percent of those losses.

Direct and indirect economic losses derived from corrosion include:

- Replacement of damaged equipment.
- Overdesign to allow for corrosion.
- Preventive maintenance.
- Shutdown due to corrosion failure.
- Loss or contamination of the product being produced.
- A decrease in equipment efficiency.
- Failure of adjacent or downstream equipment.
- The loss of natural resources, clean air and even human lives.

Application Example: The Cost of Leaks

A chemical plant undertook a leak-prevention program following a compressed air audit.

The following leaks were found:

Size	Number	Pressure
1/32"	100	90 psig
1/16"	50	90 psig
1/4"	10	100 psig

Annual cost savings from eliminating the leaks:

1/32" = $5,611
1/16" = $10,991
1/4" = $38,776
Total = $57,069

Savings calculation: # of leaks x leakage rate (cfm) x kW/cfm x # of hours x $/kWh

Assumptions: 7,000 annual operating hours, an aggregate electric rate of $0.05 kilowatt-hour (kWh), compressed air generation requirement of approximately 18 kilowatts (kW)/100 cfm, and sharp-edged orifices.

Note: The savings from the elimination of the 1/4" leaks account for almost 70% of the overall savings. As leaks are identified, it is important to prioritize and fix the largest ones first.

The Challenge

The consequences of having leaks and/or corrosion in a compressed air system underline the importance of ensuring that all connection points in a system have the most reliable and effective fittings and couplings available. In this white paper, we identify five common conditions that can cause leaks, corrosion, inefficiency and downtime. Each can be minimized or eliminated by implementing compression fittings that offer a balance of simplicity, hardness, strength and corrosion resistance.

1. Installation Error

Double-ferrule compression fittings have been the industry standard for more than 80 years. For that reason, they are often specified as replacement parts because they are most likely to be compatible with other compression fittings in the system.

This type of compression fitting consists of four precision-engineered parts designed to provide secure, leak-proof joints capable of satisfying high pressure, vacuum and vibration applications.

Problems with double-ferrule compression fittings are frequently caused by incorrect installation. Specifically:

- The parts are small and easily dropped or lost.
- There are more than 11 different ways to assemble, reassemble or connect this type of compression fitting, but only one is correct.
- The rear ferrule is typically the most common cause of performance issues due to being installed backwards or missing altogether.

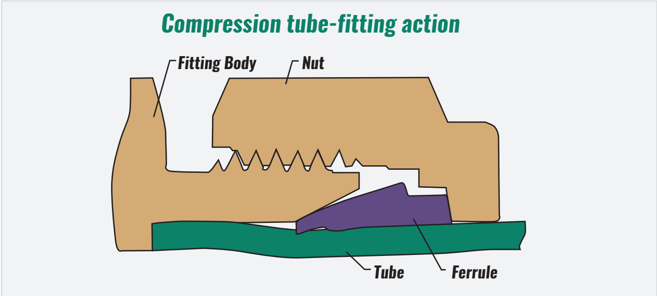
When an installation error occurs, reworking the system is a time-consuming, labor-intensive process that requires several steps:

- Troubleshoot and diagnose the problem.
- Obtain a new compression fitting or other components from stores.
- Obtain new tubing from stock.
- Return to installation point or shop.
- De-pressurize the system.
- Remove existing tubing and/or compression fitting.
- Measure, cut, debur, mark and bend tubing.
- Install replacement compression fitting into port.
- Insert tubing and make-up compression fitting.

2. Too Many Sealing Points

One of the original reasons for using compression fittings and tubing when constructing a fluid or gas handling system was to eliminate the many extra potential leak paths that existed in threaded pipe. For example, in substituting just one bend in the tubing for a 90-degree elbow compression fitting, two threaded joints—and thus, two potential leak paths—were eliminated. The same goal of eliminating potential leak paths should be carried into compression fitting design as well, so there are as few sealing points and potential leak paths as possible.

In any flareless instrumentation compression fitting, it is always necessary to achieve at least two metal-to-metal seal points because of the introduction of the third part, the ferrule. These are the seal points between the outside of the ferrule and the compression fitting body, and between the ferrule and the tube. In a double-ferrule compression fitting, it is also necessary to achieve an additional seal point between the front and rear ferrules, as the front ferrule is designed to seal to the compression fitting body and further serve as an anvil for the action of the rear ferrule in its seal to the tube. The hardened rear ferrule of a double-ferrule compression fitting must actually penetrate the tube surface in order to achieve a small grip, which is necessary to ensure a gas-tight seal.



Compression fittings grip and seal by compressing the nose of a ferrule into the tubing OD. To form high-integrity, leak-free connections that can be remade, ferrules must only slide forward during assembly and not rotate with the nut.

3. Reduced Number of Remakes

One of the design criteria of a flareless instrumentation compression fitting is that it will have a reasonable number of remakes available to the user after the initial compression fitting make-up. In allowing for these additional remakes, the compression fitting designer must arrive at one compatible solution for two design problems. First, the designer must allow for additional movement of the component parts to ensure that each component can be slightly loaded an additional amount upon each successive remake, and therefore, establish new sealing points. The designer must also limit this additional movement to ensure that too much stress is not imparted on the tube to the point where the tube collapses or compresses at a rate greater than that of the ferrule. This is especially important in the design of instrumentation compression fittings where the compression fitting will be used with thin wall tubing, which has a very low resistance to collapse.

In most cases, a double-ferrule compression fitting design does a very good job in allowing for the additional movement needed for remakes. However, this is problematic for stainless steel, which galls and seizes to itself under frictional conditions. During remakes, compression fitting nuts see high contact stress in the threads and against the ferrule. Without proper lubrication, these stresses can damage sealing surfaces and compromise sealing integrity.

4. Exposure to Vibration

If it is necessary to grip into the tube for sealing purposes, it is mandatory that this grip be isolated from tube vibration. The maximum destructive stress caused by vibration in a compression fitting is felt at the point of the tube support closest to the outboard, or tube end, of the compression fitting. This is because it is more often the mass of unsupported or weakly supported tubing that tends to have a higher amplitude of vibration than that of the attached compression fitting end. If a grip, and therefore a stress riser, exists at the outboard support, all stress caused by the incoming vibration will concentrate at this point and increase the likelihood of failure.

5. Not Matching the Materials to the Operation

As the worldwide search for oil and gas, power generation and chemical production turns to more challenging applications, there is an increasing number of situations where corrosive production environments and products are present. Many of these cases often involve significant amounts of hydrogen sulphide, carbon dioxide, brine or hazardous chemicals. The combination of high corrosivity and incorrect decisions during the design stage can lead to catastrophic system failure and significant human, environmental and economic loss. In most cases, these situations are the result of not properly analyzing the specific operating parameters and designing the most suitable equipment that utilizes components made with corrosion-resistant materials.

The Solution

Double-ferrule compression fittings are still widely used in modern compressed air systems. They are fully compatible with existing compression fittings that many plants have in stock, and when installed properly, they provide positive, reliable connections. But many of the issues that are inherent in their design can be solved by switching to single-ferrule compression fittings.

Single-ferrule compression fittings offer the same effectiveness as double-ferrule compression fittings, plus the added benefits of simplicity and ease of use. Because these compression fittings rely on only one ferrule, they have fewer interior parts. This results in only three assembly combinations, two of which (missing ferrule and backwards ferrule) are obviously incorrect to the assembler and can be easily avoided.

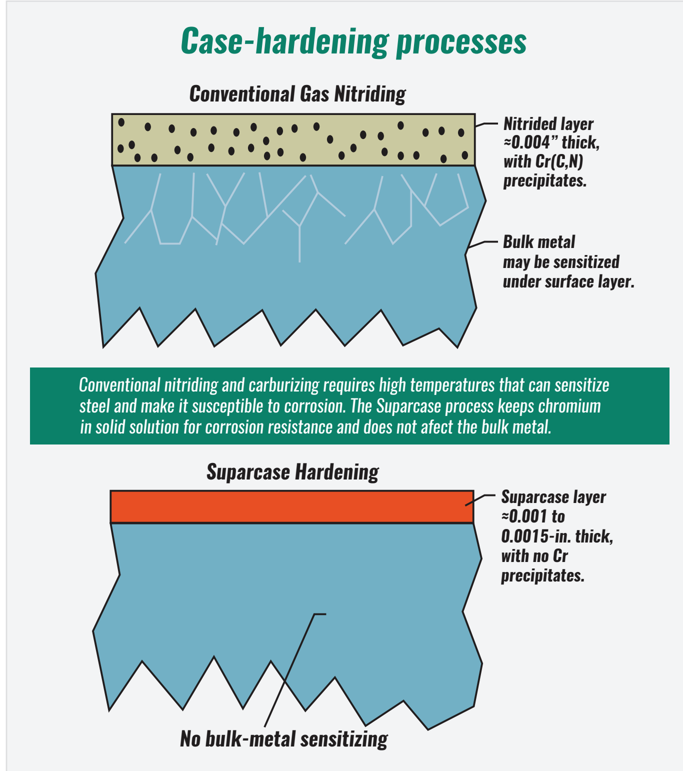
This simplicity also significantly minimizes:

- Dropped, lost or damaged ferrules during installation.
- Post-installation compression fitting replacement due to missing/incorrect parts orientation or damage to the ferrule body-sealing surface.
- Replacement due to galling of body threads.

Because they eliminate the need for an additional seal point between the front and rear ferrules, each single-ferrule compression fitting in a system contributes to increased reliability by eliminating a potential leak point. This type of compression fitting also absorbs incoming vibration by gripping the tube at the front, while the rear of the ferrule compresses the tube and shields the grip area with the compression action.

With regard to remakes, in a single-ferrule compression fitting, the ferrule becomes a "live" spring-like component. This action allows the necessary movement for remakes but restricts excessive movement by storing any additional force in the bowing action or "spring" of the single ferrule. Antigalling and lubricating coatings are also critically important to facilitate remakes with stainless-steel compression fittings. Molybdenum disulfide (MoS2) is an effective antigall or antiseize compound that owes its exceptional lubricity to a crystal structure of weakly bonded lamellae. These lamellae shear under low force to provide lubrication with an extremely low (about 0.025) coefficient of friction. The lamellae also strongly resist forces perpendicular to them and therefore don't squeeze out from between mating surfaces under extreme pressure, as do liquid lubricants. This combination of properties builds a boundary layer that effectively prevents pairs of lubricated surfaces from touching, especially under conditions of high temperature and pressure, vacuum, and corrosive environments.

To resist corrosion, ferrules in both single-ferrule and double-ferrule designs must be made with the correct alloy for a specific system. The best way to ensure correct material selection is to partner with a compression fitting manufacturer that offers an extensive range of alloys, from conventional steels to high nickel alloys and titanium for the most demanding applications.



The ferrules—especially the back ferrule in a two-ferrule design—must also be manufactured using the proper hardening process. Traditional nitriding is a method of infusing a correct and consistent level of hardness over a selected area by increasing the carbon level in the surface of the area. However, this method changes the structure of austenitic stainless steels and reduces their corrosion-resistant properties. Improved hardening processes like Suparcase allow stainless steel and other alloys to be hardened without compromising corrosion resistance of the given materials. The Suparcase process achieves a carbon supersaturated surface layer by altering the oxide passive layer on the surface of the stainless steel without creating any detrimental effects.

Conclusion

Compression fittings facilitate the numerous connections in compressed air systems used in chemical processing, petrochemical plants, paper mills, and many other industrial settings. They seal a broad range of aggressive fluids and chemicals while resisting internal and external corrosion. High-quality compression fittings hold internal pressure without leaks or failure, and users can repeatedly disassemble and reassemble them with no loss of sealing integrity.

Today, compression fittings are available from many domestic and off-shore suppliers. They often appear to be identical, though they may vary slightly in design details and manufacturing processes. But looks are deceiving. Compression fittings and their most critical component, the ferrule, also seem rather simple in form and function. In reality, they are highly engineered and require considerable design, metallurgy and production expertise in order to function properly. Not all products on the market meet the same stringent requirements.

To avoid consequences such as compensating for wasted compressed air with additional expenditures or experiencing complete process shutdowns because the compressed air system can't maintain pressure, plants must explore all types of compression fittings available today. Parts suppliers that offer both single- and double-ferrule designs as well as a variety of alloys designed to resist corrosion in different environments are best equipped to put industrial manufacturers in a position where they can get optimum performance from their compressed air systems.

About the Author:

Jarrod Taylor is the Florida Sales Manager for Fluid Flow Products. He has more than 17 years of experience in engineering and sales, specializing in filtration, automation, compressed air systems, low pressure dehumidification and specialty valves. Contact him at ***jarrodtaylor@fluidflow.com****.*

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