The Truck & Trailer OEM's Guide to Air Brake Tube Fittings

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Best practices and considerations when choosing DOT-rated air brake tube fittings to optimize brake system performance, materials cost and assembly line productivity.

A virtually invisible component on trucks and trailers, air brake tube fittings rated by the U.S. Department of Transportation (DOT) are fundamental to a truck's air brake system. Considering a typical truck requires anywhere from 60 to 100 air brake tube fittings, these connectors deserve special attention from truck and trailer OEMs.

What follows is a primer on the importance of DOT-certified tube fittings, what the DOT certification means, the locations where DOT-rated fittings may be required, the range of DOT air brake tube fittings available, and how they differ when it comes to pricing, assembly, performance, and customization.

The Importance of DOT-Certified Air Brake Fittings

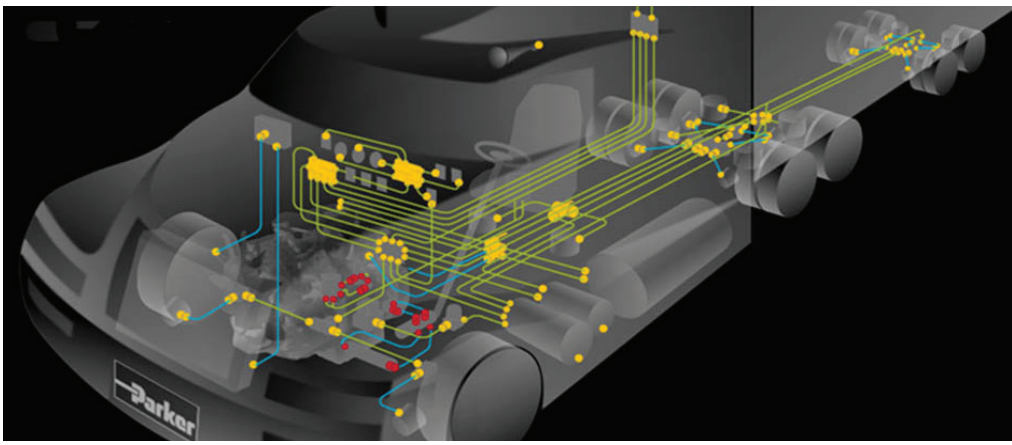
U.S. Department of Transportation (DOT) standards governing air brake assemblies of heavy vehicles have been in place for more than 50 years. Part of the Federal Motor Vehicle Safety Standards (FMVSS), the official requirements governing DOT-certified air brake fittings are published in Title 49 of the Code of Federal Regulations, in Section 571.106.

Developed to reduce deaths and injuries that could occur as a result of brake system failure attributed to hoses or hose assemblies, this section of the code designates how air brake hose and tubing, assemblies and end fittings are expected to perform.

The standards specify how air brake tube fittings and thermoplastic air brake tubing assemblies must be constructed, how DOT-certified tubing and end fittings must be labeled, and how thermoplastic air brake tubing assemblies must perform when tested against a battery of conditions.

While the code dictates performance standards for both air brake hose, tubing, and their

end fittings, DOT air brake hose and hose fitting connections are often reserved for areas requiring more stringent or specific performance capabilities, such as higher heat or tensile strength requirements, for example. Meanwhile, DOT-rated air brake tubing and tube fittings are generally specified wherever possible in trucks and trailer brake systems to meet conditions and required performance standards.



With air brake systems that are assigned their own circuit, DOT-certification is required only for the air brake hoses and tubing used to control the air brakes, and for the end fittings directly connected to those hoses and tubing.

Assuming they are located on a pressure-protected circuit and isolated from the portion of the air system supplying the brakes, tube fittings connected to non-air brake applications, like the air horn, air ride seat, and drop axles, don't need to be DOT-rated, nor do intermediate fittings such as pipe bushings or flare fittings.

Because DOT-rated fittings are more expensive than standard industrial-style fittings, there is a cost to OEMs to comply with the requirements. For this reason, some manufacturers may use standard fittings where possible to reduce costs. However, most OEMs choose not to do this to avoid the potential of using an industrial fitting in an application requiring DOT conformance. Specifically, air brake tubing, tube fittings and plastic air brake tubing assemblies must be able to meet the following requirements, detailed in the code.

Construction:

The inside diameter of any part of the assembly may not be smaller than 66% of the specified size.

Tensile Strength:

Assemblies designed for use between frame and axle or between a towed and towing vehicle must be able to withstand without separating, a pull of between 250 pounds and 325 pounds depending on nominal outside diameter. If the assembly is designed for use in any other application, it must be able to withstand a pull of between 35 pounds up to 325 pounds depending on nominal outside diameter.

Boiling water conditioning and tensile strenght:

Tubing assemblies must be able to withstand a specified conditioned tensile load without separation from end fittings with one end of the assembly conditioned in boiling water for 5 minutes.

Thermal conditioning and tensile strength:

Tubing assemblies subjected to tensile pull tests must either elongate 50 percent or withstand the specified conditioned tensile load without separation from end fittings after the assembly has been subjected to four cycles of conditioning in air at minus 40°F for 30 minutes, normalizing at room temperature, conditioning in boiling water for 15 minutes, and normalizing at room temperature.

Vibration Resistance:

Assemblies with an internal air pressure of 120 psig shall not rupture or leak more than 50 cm3 per minute at a temperature of minus 40°F, or more than 25 cm3 per minute at 75°F, after the assembly has been subjected to a million cycles of vibration testing as specified by the code. In addition, end fittings using a threaded retention nut must retain at least 20% of the original tightening torque after vibration testing.

End fitting retention:

The end fittings of a plastic air brake tubing assembly may not rupture when the assembly is filled with water and pressurized to a specified burst strength.

Thermal conditioning and end fitting retention:

The end fittings of a plastic air brake tubing assembly shall not rupture when filled with reference oil and conditioned for specified periods of time at temperatures ranging from 200°F to -40°F, and while increasing, holding, and reducing pressures inside the assembly to specified levels.

End fitting serviceability:

A plastic air brake end fitting using a threaded retention nut shall not rupture or leak more than 25 cm3 per minute when pressurized to 120 psi after five assembly cycles.

End fitting corrosion resistance:

Air brake tube end fittings many not show signs of base metal corrosion on the end fitting surface, except where the application of labeling information causes a displacement of the protective coating, after 24 hours of exposure to salt spray.

The standard also requires that DOT-rated tubing and tube fittings be labeled as such by the manufacturer, in effect certifying that the tubing and fittings conform to applicable motor vehicle safety standards.

Proof that a manufacturer's or fleet's air brake fittings conform to these DOT standards rests largely with the manufacturer, which is responsible for certifying that its products meet standards by conducting performance tests as stipulated in CFR Title 49.

Much of the federal enforcement of the standards revolves around accident investigations or investigations initiated because of complaints or reports from the field, which may be made by any individuals or organizations. In fact, most of the enforcement surrounding air brake fittings on fleets or from specific manufacturers occurs at the state level, during routine stops at weigh stations or by the commercial vehicle enforcement arm of the state police.

Truck OEMs also monitor their own performance relative to DOT standards in a variety of ways, but the amount of this oversight varies by manufacturer. Some of the oversight, for example, may be driven by rising warranty claims, customer complaints, accident reports, or maintenance reports that are linked to air brake systems or assemblies.

OEMs faced with situations indicating there may be a potential issue with air brake assemblies on their trucks may find it advantageous to conduct their own investigations around the reported problems.

First and foremost, however, truck OEMs can control their performance by specifying and installing DOT-rated fittings wherever required. In most cases, OEMs also require that tubing and fitting suppliers submit test data showing compliance with DOT standards. Many OEMs also perform some of this testing in-house.

Day-to-day controls and oversight of fitting and tubing performance may also take place when truck OEMs perform air leak down tests on air brake assemblies. During these tests, the air brake system is pressurized and then monitored for pressure decay over time. While these tests are successful at identifying leakage issues, they may not identify other performance flaws or shortcomings pertaining to air brake fittings or air brake assemblies.

Certainly truck OEMs seek to avoid performance issues with air brake assemblies at virtually all costs, because these may lead to accidents, complaints, investigations, warranty claims, or even recalls. All of these unfortunate events make it highly likely that the organization will incur unexpected and significant reparation costs, such as replacements, repairs, fines and warranty payments. Possibly one of the most significant of these is the financial cost and associated public repercussions of having to implement a recall campaign attributed to faulty air brake systems, assemblies, or components.

The Major Types of DOT Air Brake Fittings

When truck and trailer OEMs select DOT air brake fittings, a number of key considerations frequently come into play. Of these, fitting performance, price, assembly time, and the ability of a fitting or series of fittings to be customized per the manufacturer's specifications often rise to the top for many truck OEMs.

With three major types of DOT-rated air brake fittings available on the market today, a sound understanding of the way each fitting performs across these four areas can help OEMs to make wiser component choices in their systems.

All three types of air brake tube fittings are manufactured and tested to stand up to the DOT requirements, but they can be assessed in different ways when it comes to performance, price, assembly time, and customization.

Brass Compression Fittings:

Brass compression-style fittings, which have been used in the industry for decades, are trusted for their dependable performance in a wide variety of conditions and for their comparatively lower piece price. Of the three commonly used types of DOT air brake fittings on the market, brass compression style fittings are typically the most economical fitting option. However, assembling and installing brass compression style fittings is a labor-intensive process. These connections utilize a sleeve and nut in combination with the fitting to achieve a robust seal. The connection is often made by sliding the nut and sleeve onto tubing, inserting the tubing into the fitting until it's bottomed on seat, then tightening the nut until finger tight. The nut is then wrench-tightened with a specified number of wrench turns dictated by the specific fitting type and the size of the tubing.

Based on their highly specific assembly instructions and the multiple components involved, brass compression style fittings not only take time to assemble — around 40 seconds per connection — but also run the risk of being assembled incorrectly. For this reason, assemblers require some level of expertise when using this fitting type.

When assembled properly, however, brass compression

fittings are viewed as highly dependable joint connections, with sealing performance that's second to none. The mechanical bite-type seal created by compressing the sleeve onto the tubing is largely unaffected by excessively cold or hot temperatures, which may not be the case with elastomeric-based tube fitting seals.

In addition, the brass body of the fitting is impervious to rust and corrosion, and will not become brittle even in cold temperatures, making it virtually impervious to impacts from gravel or rocks. For these reasons, brass compression fittings may be specified for vehicles expected to be used in harsh, rugged, and very cold environments.

Because of their mechanically derived compression seal, brass compression fittings may also be favored for specific locations on the vehicle that will be subjected to intense heat, such as near the air compressor or engine compartment, locations where temperatures can reach upper end limits of some elastomeric based seals.

Customization of brass compression fittings is another strong point, as special fittings can be manufactured into a variety of special shapes and sizes relatively quickly. The one limitation is the malleability of brass, considering its physical properties and the complexity of the manufacturing processes required.

Brass Push-to-Connect Fittings. An advancement from the trusted brass compression fitting, brass-bodied DOT-certified push-to-connect-style fittings were introduced in the early 1990s as a way to reduce fitting assembly time and complexity, while maintaining virtually all of the other performance benefits of brass compression fittings.

Brass push-to-connect fittings, like brass compression fittings, don't rust, corrode, or become brittle in cold temperatures. But unlike compression-style fittings, these one-piece fittings utilize a collet to grip tubing, plus an elastomeric sealing mechanism to complete the tube end seal, allowing for a relatively foolproof assembly with no additional tools other than a tube cutter.

With a brass body, these fittings can stand up to impact, rust and corrosion, as do compression fittings. Meanwhile, their internal push-to-connect sealing mechanism affords a strong, dependable seal that is robust enough to meet all DOT parameters and to withstand temperature extremes.

The biggest benefit of brass push-to-connect fittings is the time savings in assembly. Attached to tubing with a simple push, the fittings may reduce assembly time by as much as 90 percent over compression style fittings, averaging 4 seconds per connection. That means an assembler who used to assemble 90 compression fittings in one hour may be able to assemble as many as 900 connections with push-to-connect fittings. Put another way, it also means one worker can potentially complete in one hour, the same number of fitting connections it would have taken 10 workers to complete.

Considering an hourly wage of about $25, the labor cost to

assemble each compression fitting connection is around $0.27, compared with just under $0.03 for each push-to-connect connection. At that rate, by switching from compression fittings to push-to-connect fittings, a manufacturer could potentially reduce its assembly labor costs from $250 per hour to less than $50.

The financial benefits are compounded when you consider that with faster assembly processes, OEMs may also be able to produce more vehicles per hour with push-to-connect fittings.

Although the unit cost of brass push-to-connect fittings is higher than that of compression fittings, most truck OEMs find the significant labor savings of this product more than make up for higher unit costs. And, when installed properly, DOT-rated push-to-connect fittings are just as reliable as brass compression style fittings in virtually all applications.

Besides helping to speed and simplify installations, push-to-connect fittings options also may provide quality benefits, by helping remove some of the variability experienced with compression-style fittings. Truck and trailer OEMs may be able to increase the consistency of the quality of their assemblies, since the fittings don't require manual assembly or counting turns of the wrench.

Another time-saving benefit of push-to-connect fittings is that they can be supplied with color coding on the tube ends of the fittings, helping to specify which sections of the air brake system the fittings are to be installed.

This not only adds further time savings by categorizing fitting connections, but also helps to prevent installation errors and rework.

When it comes to customization of brass push-to-connect fittings, these parts offer the same relative benefits as compression-style fittings: they can be quickly manufactured into custom configurations.

Composite Push-to-Connect Fittings:

The evolution of push-to-connect fittings continued with the development of composite push-to-connect fittings, manufactured with a polymer body and brass screw threads and holding mechanisms. In this way, composite push-to-connect fittings retain all the labor-saving features of brass push-to-connect fittings, in a lighter weight and lower cost product compared to brass push-to-connect fittings.

They also add greater customization potential for truck OEMs, since they allow for the creation of uniquely shaped bodies produced by injection molding processes. With significant lead times and upfront tooling costs required, custom-made composite fittings make sense when higher quantities of the custom fittings are required. However, with proper mold design, suppliers may be able to offer jump-sized versions of a part at a fraction of the cost and lead time required for the original component.

Composite fittings are particularly notable for their lightweight and durable construction, which features the same sharp biting edge as all-brass push-to-connect fittings. What's more, the weight benefits provided by composite push-to-connect fittings over brass fittings are significant enough to affect fuel efficiency and payload potential.

Composite push-to-connect fittings weigh about 43% less than brass push-to-connect fittings. With approximately 60 to 100 DOT tube fittings used per truck, that equates to a weight savings of about 7 to 9 pounds per vehicle. When you consider that some fleets number in the

thousands, the potential benefits of composite push-to-connect fittings are great and they can be passed along to end users.

For example, an article in trucknews.com relayed the story of one truck builder that previously queried several weight-sensitive customers and learned they would benefit by between $6 to $12 for every pound of weight saved. That means moving from brass to composite push-to-connect fittings could be worth anywhere from $42 to $108 per truck. Customers can apply these savings either to improving gas mileage or carrying more payload. For example, according to the article, a fuel handler could see a $95,000 increase in annual profits by gaining the capacity for an extra 50 gallons of payload per trip.

Higher Temperatures and Elastomeric Seals

In recent years, some truck OEMs have expressed concerns about increasing engine temperatures that come close to or surpass upper end temperature limits for some brands of DOT air brake push-to-connect fittings and air brake tubing.

While all DOT-rated air brake tubing assemblies must be capable of passing performance tests conducted at temperatures of 200°F, different types of push-to-connect fittings provide varying performance results at even higher operating temperatures.

For example, some truck OEMs have noted premature leakage in push-to-connect fittings manufactured with thin, wiper-type nitrile seals. Further analysis has indicated that the elastomeric seals in these types of fittings may be more susceptible to age hardening and compression set, especially when installed in higher heat areas of the truck, such as on the firewall, in engine compartments, or near exhaust systems.

Part of the concern may be based on the fact that engine temperatures have trended upward in recent years as a way for engine manufacturers to increase engine efficiency and reduce emissions.

Some manufacturers have opted to use brass compression-style fittings in these high heat areas, however it is not the only solution. Research shows that the thickness of the elastomeric seal in the fitting may have some effect on whether compression set will develop. Standard push-to-connect fittings constructed with a thicker O-ring seal have been shown to offer a more robust design than wiper-type seals, making these types of push-to-connect fittings better equipped to sustain high heat conditions without sustaining permanent damage.

In addition, some manufacturers have developed high temperature push-to-connect fitting options for truck OEMs particularly concerned about the trend of rising temperatures within vehicles. These DOT-rated push-to-connect fittings may feature bodies and O-ring seals made from specialized materials and rated to withstand operating temperatures of 250°F and above.

Assessing Port-End Thread Options

Another option for truck OEMs to consider is the type of thread pattern utilized on the port-ends of DOT air brake fittings. Two main types of thread patterns are typically offered on air brake tube fittings, and there are specific reasons, pertaining to price, availability, and performance that a truck OEM might choose one thread type over the other.

Traditionally, DOT-rated compression and push-to-connect fittings use American National Standard Taper Pipe Threads, referred to as NPTF pipe threads.

NPTF or pipe fittings feature tapered threads providing the mechanical strength needed to hold the joint together, plus the metal-to-metal sealing formed when the tapered threads are tightened against tapered port threads. This thread type requires the use of a thread sealant to seal any spiral leak paths or voids that may remain between the tapered threads on the fitting and threads on the port.

The far more common industry standard for the connection ports installed on air brake system components such as air tanks and brake valves, the choice of pipe thread fittings often arises as a matter of necessity, with the fitting thread dictated by the corresponding ports on components. As another benefit, pipe threads don't require an additional sealing mechanism, besides thread sealant, and they tend to be lower cost of the two major types.

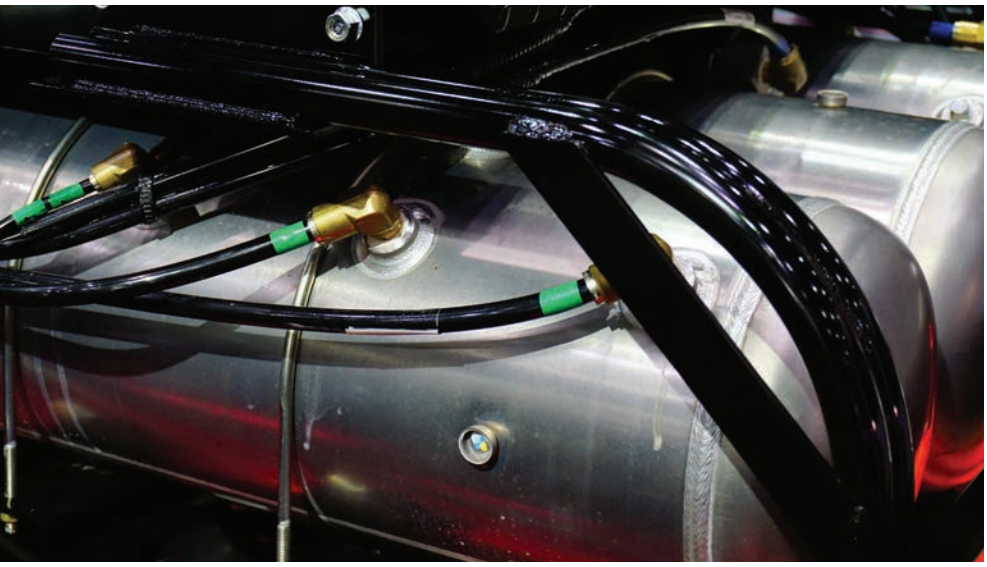
The main disadvantage with pipe threads, however, is that voids in the connection still can remain. Pipe threads are prone to leakage, especially since there is no other sealing mechanism besides the tapered threads themselves. In air brake systems, pipe thread leakage has been noted at one area in particular: port connections on air brake system air tanks, a known source of warranty claims.

Studies of these leaks have shown it may be the way these ports are manufactured that leads to a poor seal: The process requires female threads to be machined into steel spuds that are welded into the air tank. The ensuing welding process can cause the spuds to warp, which results in a poor fit.

Leakage issues like this are less of a concern with the other main fitting thread type, the straight-thread O-ring (STO). Fittings of this design have straight threads providing only the mechanical connection, but not the airtight seal. Meanwhile, the seal is handled by an elastomer O-ring seal or gasket that mates up against a defined portion of the equipment. In this way the O-ring is able to compensate for any variation in the surface of the port.

A less common option for ports installed on air brake components, STO fittings may not be specified in systems with the frequency of pipe threads. However, they have shown to offer more reliable connections where they're used: for example, warped air tank spuds have less impact when STO fittings are used. One OEM found that most of their warranty claims for air leakage went away when they switched from air tanks with pipe thread ports to tanks with STO ports.

However, the added reliability of STO fittings also comes at an increased cost to truck OEMs. In many cases switching to STO fittings may require some customization of the fittings or their respective components. These are costs and benefits for OEMs to weigh as part of their overall business plans.



Above and Beyond the DOT Rating

DOT certification alone doesn't guarantee that air brake tube fittings on trucks and trailers will perform as expected. As covered here, there are many additional factors and options to consider. Ultimately truck and trailer OEMs should use these insights about DOT-certified fittings to impact and optimize braking system performance, quality, and costs when choosing air brake tube fittings for their vehicles. Assessing and considering features like tube fitting construction, materials, assembly type, and sealing mechanisms can and should play a role in how a truck or trailer's air brake system can be expected to perform at stopping the truck and trailer over the long haul, and how they may also contribute to controlling costs as well as quality.

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Parker Hannifin Corporation
Hose Products Division
30240 Lakeland Blvd.
Wickliffe, OH 44092
phone 440 943 5700
fax 440 943 3129
hpdorders@parker.com
www.parker.com/dot