Cylinder valve outlet connections

Standardization of cylinder valve outlet connections is important to ensure product safety and integrity. The cylinder valve outlet standards separate gases based upon pressures and chemical properties encountered, e.g., flammable, oxidizing, corrosive, toxic, and pyrophoric. Standardization of cylinder valve outlet connections also permits the use of multiple suppliers by an end-use customer without special fittings, adapters or jigs.

Based on historical influences different regions of the world have established their own standards, e.g., British Standard (BS), German Standard (DIN), Japanese Standard (JIS), and French (AFNOR). This Safetygram's scope is limited to North America and CGA (Compressed Gas Association) outlet connection standards except for the ultra-high integrity connections which are globally recognized.

In North America, outlet connections are usually designated by a three-digit number preceded by the letters CGA, for example, CGA 350. Sometimes an ultra-high integrity connection is preceded by a "DISS" designation rather than the more common CGA designation. DISS is the acronym for Diameter Index Safety System. The CGA systems employ a large number of connections to minimize the ability to inadvertently connect a cylinder to a system that may not be compatible with the gas or cylinder pressure, or that may contain a gas that would be unsafe (i.e., inert gas to a medical oxygen system).

There are three basic groups of valve outlet connections: (1) connections for general, industrial compressed gas service; (2) connections for ultra-high integrity service; and (3) pin-indexed connections for medical gas service. Although this Safetygram addresses connections only for industrial compressed gas service and ultra-high integrity gas service, much of this information also applies to connections for medical gas service.

Typical connections

Most connections consist of three or four parts, depending on whether it is a bullet-nose or a gasketed connection. A bullet-nose connection consists of a valve outlet, a nut, and a nipple **(see Figure 1)**. The nut is placed on the nipple so the shoulder of the nipple rests against the pushing surface of the nut. The nut has straight threads that engage the mating threads on the valve outlet and pull the nipple against the sealing surface of the valve outlet. No sealing takes place at the threads. The gas-tight seal takes place between the nipple and the valve outlet seat at a very small contact circle where they touch. The success of this connection depends on the surface condition of both the nipple and the valve outlet sealing area at the point of contact.

Figure 1: A Typical Bullet-Nose Connection.

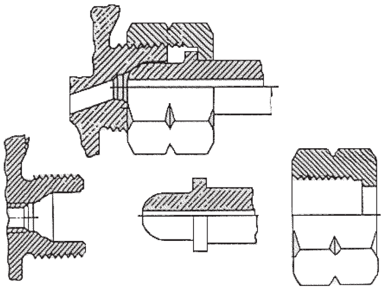
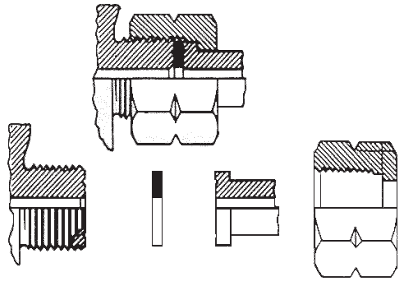


Figure 2: A Typical Gasket Connection.



Some bullet-nose connections have a soft-tipped nipple or an O-ring on the nipple to improve the seal. This allows the connection to be made without a wrench, using a nut equipped with a handwheel. These connections are called hand-tight connections.

A gasketed connection has four parts: the valve outlet, a nipple, a nut, and a washer **(see Figure 2)**. The nipple of the gasketed connection is not bullet-shaped as in the bullet-nose connections, but is flat to compress the gasket. The valve outlet sealing area is also flat. The nut fits on the nipple so the shoulder of the nipple rests on the pushing surface of the nut. The washer is placed on the flat surface of the nipple inside the nut. The straight threads of the nut engage with the mating threads of the valve outlet and are tightened to compress the washer between the two sealing surfaces.

Standard industrial valve outlet connections are designed to provide a “bubble-tight” connection, which refers to leak-checking the connection with a soap solution or by immersing it in water. Bubbles indicate a leak. Leak detection solutions vary in their ability to detect leaks. However, leakage rates for standard connections range from 1×10^{-3} to 1×10^{-5} cc of helium per second. Smaller leak rates can be obtained with these connections, depending on surface finishes, washer materials, and mechanical condition. However, achieving smaller leak rates can be difficult and inconsistent. This is one of the primary reasons why the ultra-high integrity outlet connections were developed.

Force required for seal

One of the most confusing issues concerning outlet connections is how much force one should apply to achieve a seal without damaging the connection. **See Table 1** for torque guidelines for conventional CGA outlet connections (data from CGA Technical Bulletin TB-14).

Variables that affect the force required to achieve an acceptable seal include materials of construction, contact surface conditions, thread condition, and machining quality. Materials of construction influence several aspects of the connection. Harder materials such as stainless steel, have less lubricity than other metals, which causes higher friction in the thread engagement. Lubricity also affects the durability of the sealing surfaces as well as the ability of those surfaces to mate and seal; i.e., harder materials of construction are more difficult to seal. These materials are also often harder to machine, making it more difficult to produce smooth threads. The surface finish and condition at the point of sealing contact are also critical. Softer materials such as brass are more easily damaged yet are also more malleable, so they can actually deform to minimize imperfections. Machining quality is usually not a problem with the sealing surfaces of outlet connections, but it may impact the threads. This is especially true for the harder materials of construction. Their thread surfaces may be rough and can cause higher-than-normal friction or even galling when making and breaking connections. Damaged or badly worn threads can also cause problems with sealing.

Some bullet-nose connections have soft tips or O-rings on the nipples. The nuts on these connections usually have handwheels mounted on them. These connections are sometimes referred to as "hand-tights" because they are designed to be connected and sealed without the use of tools (recommended tightening torque is 8 to 15 foot-pounds or 11 to 20 NM) for hand-tight connections.

If your connection requires more force than the values suggested in **Table 1**, inspect the connection for marred, dirty, or worn sealing surfaces, damaged threads, or compromised washers. Replace any damaged or worn components.

Table 1: Torque Guidelines for Sealing CGA Outlet Connections

CGA Connection	Recommended Torque		Maximum Torque	
Number	ft–lb	NM	ft–lb	NM
110 (washer)	10	14	15	20
165	8	11	10	14
170 (washer)	10	14	15	20
180 (washer)	10	14	15	20
182	15	20	25	34
200	25	34	35	47
280	25	34	35	47
290	30	41	45	61
295	25	34	35	47
296	35	47	50	68
300	35	47	50	68
320 (washer)	20	27	30	41
326	25	34	35	47
330 (washer)	20	27	30	41
346	35	47	50	68
350	35	47	50	68
410	35	47	50	68
440	40	54	55	75
450	40	54	55	75
500	35	47	50	68
510	35	47	50	68
520	35	47	50	68
540	40	54	60	81
555	40	54	60	81
580	40	54	60	81
590	40	54	60	81
621	35	47	50	68
622	35	47	50	68
624	35	47	50	68
625	35	47	50	68
626	35	47	50	68
660 (washer)	30	41	45	61
670 (washer)	30	41	45	61
678 (washer)	25	34	35	47
679 (washer)	25	34	35	47
705 (washer)	40	54	60	81

NOTE: The torque recommendations for gasketed connections shown are for elastomeric materials (fiber, nylon, PTFE, PCTFE). For metallic gasksets (lead, copper) the recommended tightening torque is 30-45 ft-lb (41-61 NM). The CGA data is based on testing conducted in a laboratory environment using new connecting parts. Due to many variables, a connection in the field may vary from these results. Therefore, the end user must verify the leak integrity of a connection before putting any cylinder into service based on the data in this table.

Washer materials for washered connections

With washered connections, the material of construction of the washer is important, both for compatibility with the gases in use and for its mechanical properties.

The most common CGA washers are made from fiber, nylon, PTFE (Teflon®) or PCTFE (polychlorotrifluoroethylene). A typical metallic washer is made from lead or softened copper. Each material has its advantages and disadvantages. The first requirement for a washer is compatibility with the gas being handled. Some of the other properties to be considered are leak integrity, permeation, cold flow, off-gassing, particle shedding, and cost. The tightening force required for washered connections is dependent on the washer material being used (see note in Table 1).

Air Products recommends specific washer materials for certain applications. Nylon washers are recommended for medical yoke connections while fiber washers are commonly used in carbon dioxide service. PTFE is compatible with most gases and is the most common washer material used with specialty gases. However, PTFE has some properties that can make it a poor choice for a washer material. It has a tendency to cold-flow. Cold flow occurs when pressure is applied to the material, and it flows away from the pressure. This can cause leaks to develop as the washer moves, reducing the sealing pressure on the washer. The flowing washer material can also restrict flow paths and jam in the connection threads. PTFE is also permeable to moisture and oxygen, which can cause microcontamination in sensitive processes.

When PTFE washers are used in systems using water-reactive acidic or basic gases, moisture can cause the formation of corrosive acids or alkaline liquids in the system. For most specialty gases, PCTFE is recommended over PTFE because it is less permeable to oxygen and moisture and evidences less cold flow. This leads to better leak integrity and reduces contamination concerns. In some applications, PTFE mixed with a solid filler material—such as calcium fluoride or brass—is used to reduce the cold flow of the PTFE. Lead or annealed copper washers are most often used in fluorine and other reactive fluoride service.

For best results, install a new washer with every cylinder change.

For many washered connections, overtightening can result in the washer being compressed into the bore of the connection, limiting or even stopping the flow of gas. Overtightened washers can be distorted into the connection's threads, making disassembly or washer removal difficult. To prevent this from happening, avoid excessive tightening force and install a new washer with every cylinder change. Washered connections do not mechanically bond the valve and connection with the same force as bullet-nose connections. This means if the downstream equipment twists or vibrates, these connections are more likely to develop leaks than bullet-nose connections.

DISS Connections

Ultra-high integrity service, or DISS connections, are designed for applications where the requirements for system leak integrity are very high, primarily in the semiconductor industry. A DISS connection is a washered type that consists of the valve outlet, nut, nipple, and washer **(see Figure 3)**. The sealing contact surfaces are much more sophisticated than those of a general, industrial connection. Metallic washers may only be made of annealed nickel and have highly polished surfaces. The sealing points on the nipple and valve outlet are composed of highly polished torroidal beads. When the nut is screwed to the valve threads, it pulls the nipple into the valve outlet, compressing the washer between the two beads. The beads are driven into the washer, allowing the polished beads to form a crush seal onto the washer.

The key to successful sealing of the DISS connection is the extremely smooth finish of the sealing surfaces. These surfaces must be protected to maintain high leak integrity. It is essential to use a new washer each time the connection is tightened because the softened nickel washer becomes hardened after each compression. On installation, care should be taken to ensure the washer is kept clean, properly placed, and is flush with the pigtail nipple end around the entire circumference. The washer retaining ring should keep the washer snuggly fitted into the nipple when the washer is installed properly. It should not be loose or be able to change position. For highly reactive or toxic gases, nickel washers are strongly recommended.

Controlled tightening torque or force is another critical element with successful DISS connections. Sufficient force is required to push the metal sealing surfaces into the washer, but too much force will damage the bead surfaces. Therefore, torque wrenches should be used for tightening DISS connections. The recommended tightening torque is 35 foot-pounds (47 NM) with a nickel DISS washer and 12 to 15 foot-pounds (16–20 NM) for a PCTFE washer. Slightly higher forces may be used without immediate damage to the connection components, but nickel washers should never be tightened with more than 45 foot-pounds of force (61 NM). If a required seal can be achieved without exceeding the maximum force, the connection can be used. If an adequate seal cannot be made, try a new washer. If the new washer does not work, replace the connection and/or cylinder.

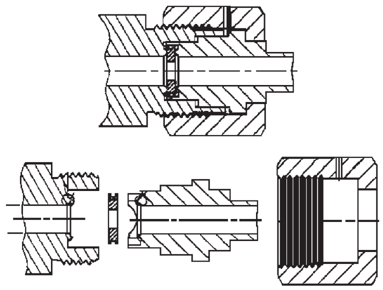
Outlet seals

Outlet seals are an important part of many valve outlets. They are designed to provide a secondary seal in the event the cylinder valve develops leakage through the valve seat when not in use and during transport. The outlet seals are designed to safely contain full cylinder pressure.

Transportation of Dangerous Goods regulations, including U.S. Department of Transportation (DOT) regulations, require that outlet seals be properly installed on many products' valve outlets during transport. It is also important that they be reinstalled when the cylinder is removed from service.

Where used, outlet seal washers are critical to seal the valve. Make sure that any washers required are present and in good condition. Make sure that any outlet seal is properly tightened to the same torque requirement as the CGA connection for the particular valve outlet. If the washer is not present or must be replaced, select a replacement compatible with the product involved. If you do not have a washer, contact your supplier for a replacement.

Figure 3: Typical Ultra-High Integrity Connection, (Diameter Index Safety System, DISS)



Safety and use considerations

The success of the connection can be ensured by considering the following items:

- Prior to assembling a cylinder outlet connection, inspect the seal ing surfaces of both the valve out let and the connector for defects (cuts, scratches, dents, flattening) that may allow a leak. Do not connect parts that appear to be damaged.
- The nut-to-nipple contact surfaces on the connection must be smooth, clean and free from wear. A simple test is to twist the nut while exerting some pressure against the nipple contact surface. Any roughness or "sticking" may indicate damage to the nut and/or nipple. This damage could prevent the full closure force from being delivered to the sealing surfaces when the nut is tightened to the proper torque.
- For gasketed connections, the washer material must be compatible with the service gas. Especially for oxidizing gases or ultra-high integrity service, the washer must be clean and free of contamination. The washer must not be deformed and should have no noticeable marks or marring on the sealing surfaces on either side of the washer.
- Especially with non-DISS connections, a second wrench should be used to prevent the nipple from rotating in the outlet during assembly.
- Before introducing highly reactive or toxic gases, connections should be leak checked with an inert gas at or above service pressure and with a suitable leak detection method. If leaks are found, the connection must be depressurized, repaired and retested before use. Do not attempt to increase the torque to achieve a seal. If the leak is detected after the procedure is repeated, the connection should be considered damaged. Contact your gas supplier for further assistance.

For ultra-high integrity (DISS) connections, the following items must also be considered:

- The nut/nipple combination should fit smoothly into the outlet connection and be aligned without forcing in all planes. The nut should run onto the cylinder outlet threads easily by hand without exerting bending force on the nipple.The sealing beads should be parallel and aligned before connecting the nut. Misalignment can prevent proper sealing and cause damage to the sealing urfaces and threads. For DISS connections assembling a misaligned connector ("wiggling" the cylinder or nipple while pushing the nipple) can cause damage to the outlet alignment slots.
- For DISS connections, insert a washer into the nipple by compressing its retaining clip and sliding the washer into the nipple so the open ends of the retaining clip are opposite the thumb notch access in the nipple. Use minimal flows when back-purging to prevent dislodging the washer. When removing washers, always use the notch provided. On washer removal with a tool, care should be taken to avoid defacing or deforming the sealing beads.

- DISS connection nipples must include the antirotational keys. This also applies to gas-tight outlet caps when using metal washers. These anti-rotational keys are meant to prevent rotation between sealing surfaces during assembly when normal clockwise tightening torque is applied.
- Heavy flexhoses, regulators or other equipment should be supported after assembling a DISS connection to reduce side-loading that may allow leaks to develop during use.

CGA technical support

The CGA has published two technical bulletins: "TB-14: Torque Guidelines for CGA Outlet Connections" and "TB-9: Guidelines for the Proper Handling and Use of the CGA 630/710 Series Ultra-High Integrity Service Connections." Both bulletins are available at www.cganet.com.

Torque guidelines in **Table 1** are from CGA's Technical Bulletin TB-14.

Standards for reference

Compressed Gas Association CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*.

International Organization for Standardization ISO 10692-1, *Gas cylinder valve connections for use in the micro-electronics industry—Part 1: Outlet connections*.

British Standard BS 341-3, *Transportable Gas Container Valves—Valve outlet connections*.

European Industrial Gases Association EIGA, *Valve Outlet Connections for Gas Cylinders Doc 97/03*.

German DIN 477-1, *Gas cylinder valves rated for test pressures up to 300 bar; types, sizes and outlets*.

Japanese Industrial Standard JIS B 8246, *High Pressure Gas Cylinders—Valves*.

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