

# Ball valves for subsea applications

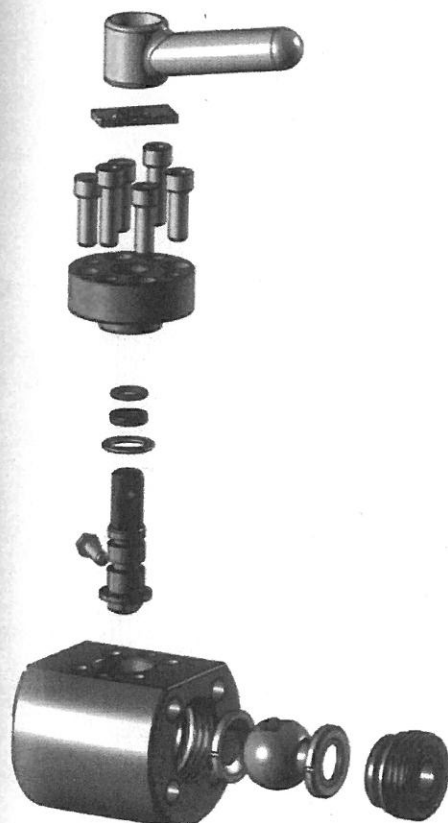
In this article, the author describes the numerous advantages and options of various ball valve types. He also touches upon the importance of metal soft seats as well as explaining the subsea applications for these valves.

By Mr. Karel van Wijk, Advanced Valve Solutions

## Compact ball valves

Ball valves are one of the most commonly used valve types and can be found in use in a wide variety of industries. A simple 90° operation and the possibility to have uninterrupted flow pass through the assembly make this valve a popular choice for flow control applications.

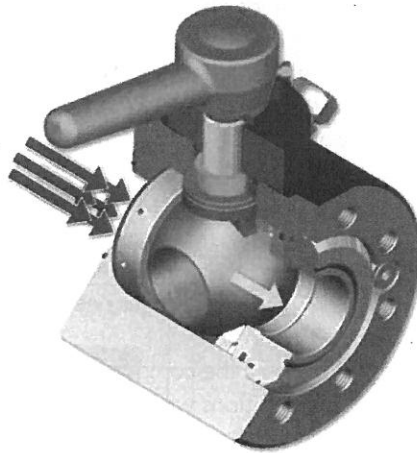
To fully understand the construction of a ball valve, it is key to analyze the different functions and components of the valve. The main components of any ball valve include a valve body, two seats, stem and handle, a bonnet, and of course the ball itself.



Ball valve construction.

## Floating ball valves

There are two main types of ball valves, the floating and trunnion style. The simplest form being the Floating, because of a design that utilizes less mechanical parts.

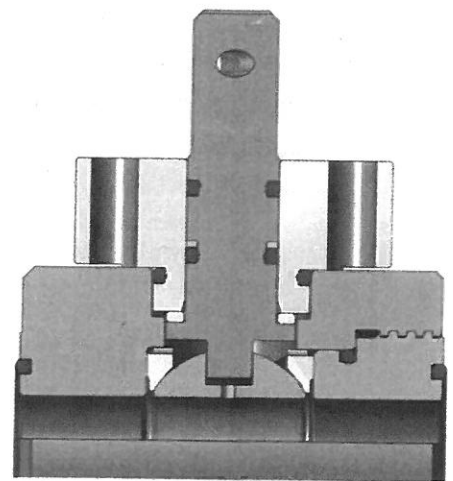


FLB ball valve.

The basic principle behind a floating ball valve is a design that, when turned to the closed position, has a ball that will be pushed by fluid under pressure into the downstream seat. The seat, typically made of some type of polymer, is cut into an angled shape that when mated with the ball will create a positive sealing surface. Varying production rates make it difficult to determine how much torque is needed to stroke the valve as the ball is being pushed against the seat. Floating valves are typically used in applications that call for smaller bore sizes and lower pressure classes. An over-sized handle or larger actuators can be used to combat higher torque levels. The surface pressure stress ( $\sigma$  in psi) on the soft seat is limited. If over-pressured, the seat material will deform and cause the valve to fail. Changes to seat shape and material are available to handle higher operating pressures. Another issue that can occur in a floating

design is trapped pressure resulting from the fluid in the spaces around the closed ball compressing the seats into the valve body. If the pressure becomes too high, the valve could potentially lock up and not function properly. A solution to this can be found with the installation of a seat carrier; outfitted with an "L" seal between each side of ball and the valve body. The carrier design allows for trapped pressure in the ball cavity to be released around the "L" seal and allows the seat the flexibility needed to create a positive seal while maintaining acceptable torque levels.

The solutions to ensure proper sealing at both high and low pressure applications can be very interesting. The soft seat material is machined with a slightly bigger radius than the ball itself to limit the seat surface contact at low pressures. A sufficient seal is created with only a small part of the seat material touching the ball. The ball is more heavily pressed against the seat when higher pressures are applied. The seat becomes fully supported by the seat carrier yielding slightly because of the angle. The radius of the seat is now on full contact with the ball, while keeping the surface pressures within an acceptable range.



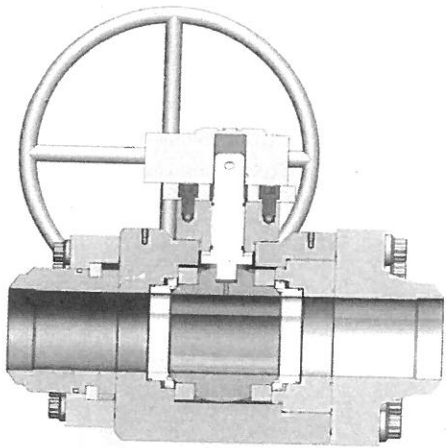
Close up of floating ball valve seat/ball relationship.

Therefore, proper sealing is achievable in both low and high pressure applications. The biggest disadvantage to the floating ball design is the rising torque levels that take place during the first few hours under pressure.

## Trunnion ball valves

The second of the main types, the trunnion ball valve, derives its name from trunnion blocks mounted directly on top and bottom of the ball. These blocks hold the ball in a fixed position and only allow for the rotational movement of a 90° turn. A positive seal is achieved when fluid under pressure pushes the upstream seat into the ball. This is the reverse of the floating design where the ball "floats" into the downstream seat.

The seat assembly in the trunnion valve consists of a seat ring that is pressed into a seat retainer. The seat retainer has grooves on the backside for O-rings to seal the seat against the body. The seat assembly is spring loaded and remains in constant contact with the ball. This allows for sealing even at very low differential pressures. Through proper engineering calculations, the optimal geometry can be calculated to maximize the reliability and seal ability, while insuring low, constant torque levels.

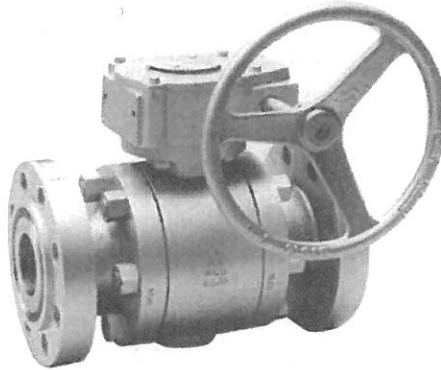


Above is a close up of the trunnion ball valve seat/ball relationship. Also pictured are two types of compact style end connections, Swivel Flange (left) and Weld-Neck (Right).

This design allows for the pressure load on the ball to be transferred through the trunnions to the bearings into the trunnion blocks and finally into the body. The bearing material is specially designed to withstand very high surface pressures. The trunnion blocks and bearings remove the limitations imposed by the floating design. This allows for the larger diameters and higher pressure classes to be used. While typical configurations utilize soft seats, metal to metal sealing systems are available as well.

## Traditional vs. compact

Traditional ball valves are assembled in a three piece design that is acceptable by API 6A & 6D standards.

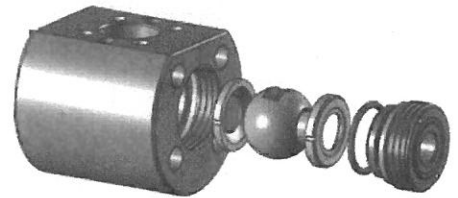


Traditional style 3-piece ball valve.

The three sections consist of a middle section, which houses the ball and trunnions, as well as two end closures that include seat assemblies and are bolted to the valve body or center section. After these three components are bolted together, they are then bolted into the pipeline. The overall weight of the assembly will add to the weight of the companion weld neck flanges needed to place this valve in line.

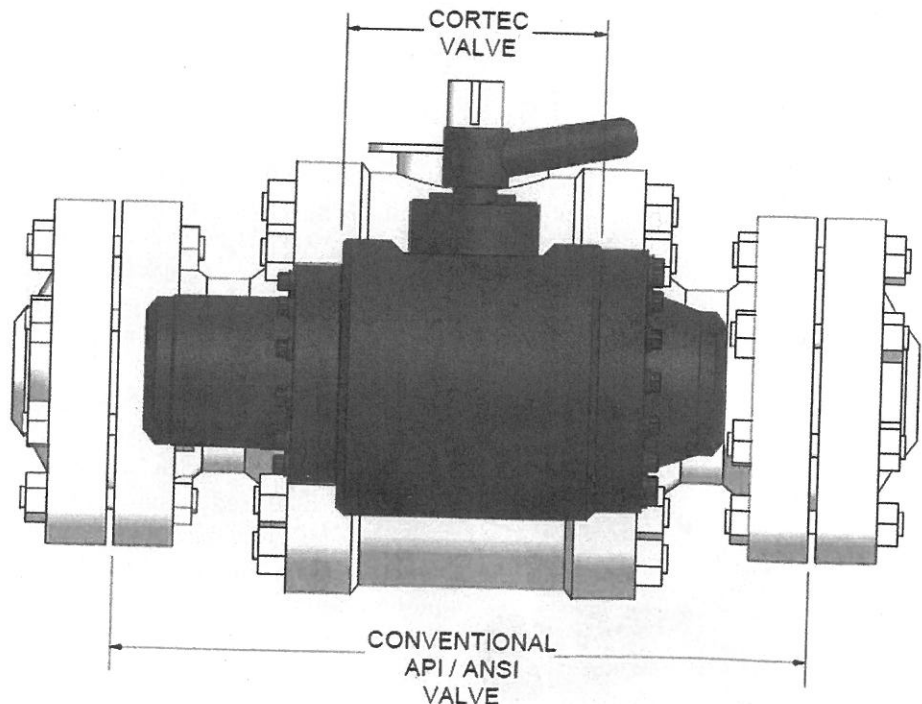
The advantage of the compact design comes in applications where space and weight are limited, such as offshore platforms. Compact valves house

all components in a small, robust body design. The internals are held in place by a threaded retainer (in the Cortec compact manifold valves) that is tightened into the body. Compact designs are significantly smaller and lighter when compared to the space and weight required for bolting a three piece valve assembly that needs companion flanges. Further space is saved by utilizing flanges that bolt directly to the valve body and weld into the pipeline. The compact design is machined out of high quality forged or wrought materials. This method aids in designing for substantially smaller valve assemblies. It also offers a high quality fully traceable method to manufacture valves. Traditional



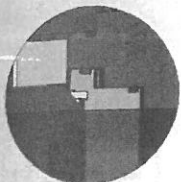
This diagram displays how the compact ball valve houses all pressure containing components inside of the body.

valves are made from materials produced from castings. This process produces a larger product that could be prone to quality issues.

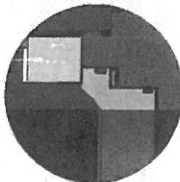


Comparison of compact vs. conventional valve.

## Metal & soft seat options



DETAIL C  
STANDARD SOFT-SEATED

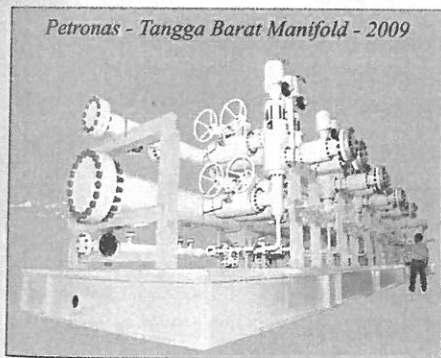


DETAIL C  
OPTIONAL METAL-SEATED

Compact ball valves are available in both metal and soft seat configurations. This design versatility allows for the valves use in many different applications and operating conditions. The dimensions of both metal and soft seated valves are the same, making modifications possible without needing to change the valve body.

## Oil and gas production applications

The compact design is utilized in many applications in the oil and gas industry, especially offshore valve manifolds. Using smaller, compact valves allows for smaller, compact manifolds. This gives back much needed space and weight allowances of offshore facilities. Compact check

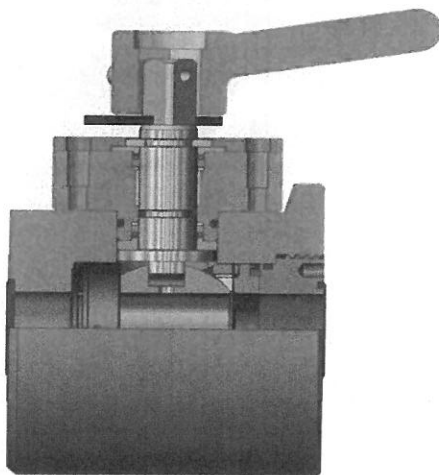


and poppet diverter valves allow for a complete compact manifold that offers safety, quality, and reliability in a system with multiple lines and headers.

## Subsea applications

The compact ball valve is suited for not only topside, but subsea environments as well. The functionality of the valve remains unchanged, but a few components are modified to withstand the external pressures involved with deep water subsea environments. The difference in the valve assemblies occurs in the bonnet/stem assembly. A longer stem with additional slots machined around the outside is installed. Locking rings are then

placed in the slots and a retaining plate is then placed over the subsea bonnet and bolted to the assembly. The subsea stem has O-rings in place to prevent water ingress from the outside of the assembly. The retaining plate with locking rings is used to prevent external pressures from pushing the stem into the ball and causing misalignment in the assembly. The external pressure could also cause large increases in torque if allowed to push the stem into the valve.

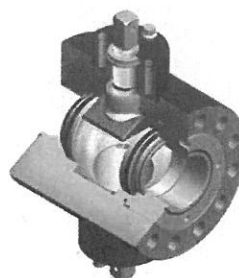


Example of a subsea valve.

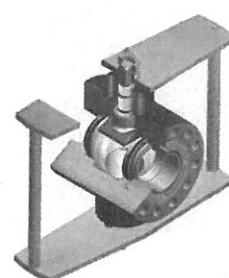
Subsea compact valves can be operated by a variety of methods. Human divers can operate the valves in shallow water conditions. In deeper water environments, ROV friendly actuators and gear boxes



Valve with ROV bucket.



Double stem ball valve.



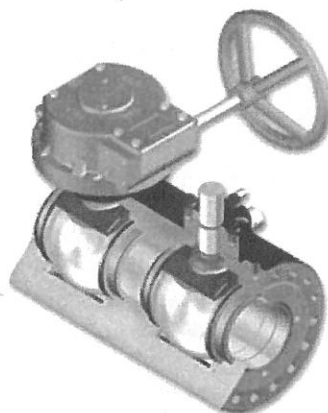
Valve with knock-over handle.

can be installed. Subsea actuators are also available to remotely operate the valves. Additional subsea designs include

double stem versions that allow multiple access points for valve operation. This aids in situations where one entry location becomes blocked or inaccessible.

## Double ball valves

An additional feature of the compact ball valve is the ability to manufacture a double ball valve assembly. This assembly houses two ball valves in one common body.



Double ball valve

The double trunnion ball valve offers redundant block & bleed capability and the ability to verify seat integrity.

This option is available in floating, trunnion, and subsea models. Double ball valves give users block and bleed capability in floating versions, as well as redundant block and bleed capability in trunnion models. Users are given double insurance of sealing

integrity and safety. It is also possible to have one valve with metal seats and the other with soft seats.

## About the author

Karel van Wijk, born in 1958, studied mechanical engineering. After his MBA he joined various valve stockists and a boiler maker. Van Wijk started Advanced Valve Solutions in 1999, specializing in engineered valves and control valves for the water-steam cycle and subsea applications.

