# Wafer style axial flow check valves vs. dual disc check valves

## Hydraulic shock in 60 million gallons per day water treatment facility

*In 2000 a South Eastern US County Water Department, located in one of the fastest growing areas in the US, began operation of their wastewater treatment facility. Upon completion in 2006, the membrane plant was operating at a licensed 60 million gallons per day (mgd) capacity with an average of 30 mgd since completion. In 2010 the plant began having issues with water hammering and began reviewing alternatives to the existing design in an effort to resolve the issue.*

*Jim Bachmann, DFT Inc. Exton, PA*

The membrane plant at the wastewater treatment facility in question was operating at the following capacity:

- Licensed capacity of 60 million gallons per day (mgd).
- Average 30 mgd since completion.
- Membranes treat plate clarifier effluent and are designed to treat 40 mgd. Membranes effluent then goes through three more processes before it is returned to a lake or river.
- Total of 16 trains.
- The reinforced hollow-fiber membrane acts as a physical barrier, producing the highest quality effluent. In addition, the system's modular design allows membranes to be added as the capacity requirement increases, drastically reducing upfront development costs.

The membrane plant utilizes a combination of 20 pumps with associated check valve protection to provide membrane filtration, backwash pulse and clean water discharge for the site.

Starting around 2010 the plant started having issues with water hammering, which resulted in the following:

- Check valve spring failure every 2-3 months.
- Repair and replacement of check valve every 3-4 months.
- Increased routine for tightening loosened flanging due to hydraulic shock in system.
- Retuning of instrumentation due to hydraulic shock in system.
- Loss of capacity due to increased maintenance routine.

### Seeking a solution

In 2015 the plant began reviewing alternatives to the existing design in an effort to resolve the issue and considered use of wafer style axial flow check valves.

Axial flow check valves were considered due to the ability to minimize and/or reduce the effects of water hammer based on the difference between an axial flow and dual disc trim. In addition, the valves were to be installed in a vertical flow up position in order to increase the number of pipe diameters between the pump discharge and the check valve.

To understand the improved performance of an axial flow check valve in minimizing water hammer, you must consider the fundamental difference in the trim design. Just as ball valves, globe valves, gate valves, etc. have different flow characteristics, so do check valves. Check valves can be classified into two basic categories, swing checks and axial flow. Within each of these types there are subcategories based on specific trim designs. As an example: a swing check, versus a tilting disc, versus a dual disc check valve. Each of these types has a trim component which swings out of the flow path hence the term "swing checks". In the case of axial flow check valves the trim moves parallel to the axis of the flow path. Only non-slam silent check valves are designed this way.

### A comparison

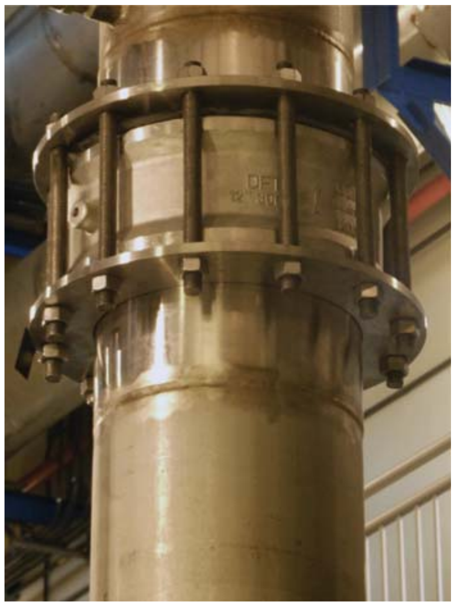
In comparing these two designs, we must examine the movement of the trim under process conditions. In the case of swing check valves, as the process pressure and flow increases the trim swings out of the flow path in order to accomplish flow through the piping. Each degree of rotation of the disc reduces the effective area in

*The initial installation with dual disc check valves which caused excessive maintenance and replacement due to hydraulic shock/water hammer.*

contact with the flow stream while the valve is opening. In the case of the dual disc check valve trim which rotates about the center hinge pins there is a helical spring which is used to close the valve upon reduction of upstream flow and pressure. So as the valve begins to open moving from 0 to 90° there is less and less area in contact with the flow path however the spring is increasing force as a result of the rotation of the disc around the hinge pins and effectively pushing the disc closed which typically causes a flutter type movement of the trim. Upon reverse flow or pump shutdown the opposite effect occurs as the spring begins to rotate the two disc halves towards the upstream seat. There is an increase in the effective area for every degree of rotation toward the upstream seat and therefore the backflow or back pressure against a changing area causes an acceleration of the disc to the upstream seat and a slamming effect during the valves closure.

This is not unlike a door in your house that slams shut due to cross ventilation occurring in the house. It does not move in a linear rotation to the doorjamb but actually accelerates toward the doorjamb producing the slamming noise. Of course in your house you might feel some vibration in the room due to the compressibility of the air, but in a liquid non-compressible environment, the slamming effect causes a hydraulic shock wave to occur upstream and downstream of the piping installation. In the case of an axial flow check valve, the trim moves parallel to the flow path and remains perpendicular to the flow direction throughout the cycling of the valve from on to off and including reverse flow. Therefore the effective area and the force vectors on that area are opposed by a linear spring in the opposite direction. So the typical operation would be characterized by valve moving to a full open position based on upstream pressure and flow conditions acting on a perpendicular disk opposed by a spring in the opposite direction. Upon reverse flow or pump shutdown once the spring force overcomes the upstream pressure, the trim begins to move to the upstream seat without any effective change in area and as a result the valve closes prior to the back pressure or reverse flow contacting the back side of the trim. However there is still momentum associated with the media moving toward a closed valve but without the additional hydraulic shock wave due to the valve slamming shut. Therefore, the effect of water hammer is minimized and or potentially eliminated. This difference between the two trim types was critical to resolving the issue with water hammer at the membrane plant. In addition to resolving the issue with water hammer, the valves would also be installed in a vertical flow up orientation. Axial flow check valves are not limited by vertical flow up installations.


*The current installation updated with DFT axial flow check valves installed in a vertical flow up orientation, eliminating the hydraulic shock/water hammer in the membrane facility.*



*A close-up view of one of the 20 axial flow check valves installed at the membrane plant.*

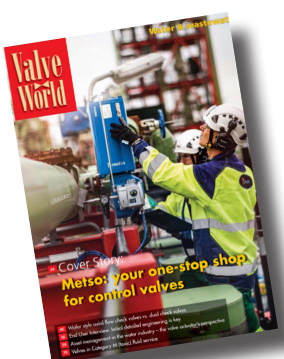
## The issue resolved

The valves were installed over a period of six weeks and were phased-in to ensure the plant was not completely shut down during that time. As each pumping module was reconfigured and commissioned, operations was able to evaluate and compare the improved performance and reduced effects of water hammer with the other valves yet to be replaced. During the course of the installation the operators commented not only on the reduction in vibration, but a reduction in the amount of noise associated within the plant as a result of the use of the axial wafer style check valve. One operator commented, "at one point the system was so quiet we wondered if the pumps were running". At the time of writing the valves have been installed for just over a year without any issues associated with repair of the valves and or water hammer, flange leaks or instrumentation calibration issues.

*The photos show both the previous and current installation of the valves at the membrane water treatment facility.*

*DFT Inc. is a manufacturer of industrial check valves and control valves.*

*www.dft-valves.com*

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DFT® INC.

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