The development of valves for pipe networks in water supply

by Oliver Jäger

1 Introduction

In water supply, valves have, for centuries now, been a vital part of the safe transportation of drinking water. Without reliable components, security of supply and the quality of drinking water would not be as good as they are. Breakdowns of water supply systems are in fact rather rare events. Under the aegis of the DVGW (the German Technical and Scientific Association on Gas and Water), the water supply companies and the producing industry have made continuous improvements in the components. These improvements have been reflected in the requirements and tests laid down in the sets of rules. The sets of rules give a picture of the state of the art and are an assurance for users of a high standard of quality when selecting the components. This is equally true of the use of ductile cast iron materials.

2 Valves

If today’s valves are compared with those of around 25 years ago, it can be seen that there have been few changes in their basic functions. Nevertheless, valves of the current generations have little in common with their predecessors.

The efforts that are made to constantly improve the quality of our drinking water and to reduce the costs of maintaining and renovating the pipeline systems have been reflected in a wide variety of changes made to the valves. In this way, the lamellar graphite (grey) cast iron material used mainly for those body parts of valves which have to withstand pressure has given way to high-grade ductile cast iron. In this connection, there have also been further developments in the corrosion protection of these body parts. Epoxy-resin-based paint finishes with film thicknesses of around 80 μm were originally used but these were of only limited suitability when in long-lasting contact with drinking water and development has progressed from these to materials specifically designed for drinking water. Epoxy-resin-based powder coatings with a film thickness of at least 250 μm are currently being used. In working with the coatings, the leading valve manufacturers follow the rules laid down by the “Gütegemeinschaft Schwerer Korrosionsschutz (GSK)” (GSK Quality Association for Heavy Duty Corrosion Protection) [1]. As an alternative, an enamel finish specifically designed for use on valves in contact with drinking water has been developed.

Also with corrosion protection and drinking water hygiene in mind, the materials used for connecting components, such as bolts for connecting valve bodies, have been changed from carbon steel to stainless steel, of a minimum of A2 grade.

In the field of sealing components, development has advanced from fibrous materials to elastomers. As well as the requirements which they have to meet in respect of their operation, modern-day elastomers also have to meet the German Federal Environment Agency’s KTW recommendations [2] in respect of toxicology and drinking water hygiene and the requirements laid down in DVGW Arbeitsblatt W 270 [3] in respect of microbiology. The same is, by the way, also true of coating materials of epoxy resin.

In the field of connections to other pipeline components, what have established themselves as the connections of choice are, as well as the original flange connections, push-in joints suitable for the particular pipe material concerned.
2.1 Gate valves

As well as the changes to the materials which were described above, there have also been changes in principles of design which can be seen in the gate valves used in drinking water supply (Fig. 1). In this way, the gate valves with metal seats which were used in earlier days have given way to resilient seated gate valves. The first step in this respect was to provide part of the shut-off wedge with a coating of rubber in the area where it sealed against the seat, thus making it possible for the floor of the “tube” through the body of the valve to be smooth. This ruled out the possibility of deposits building up in the so-called “Schiebersack” or gate-valve seat trough and causing leaks. The seal between the body and the shut-off wedge thus became unaffected by solids in the pipeline.

Another significant step in the development process was the introduction of maintenance-free stem sealing by means of O-rings mounted in non-corroding materials. For the material of the stem, brass was replaced by stainless steel.

2.2 Butterfly valves

Butterfly valves (Figs. 2 and 3) have followed a similar pattern of development to gate valves. The original metal seat in the body was found to be very expensive to produce and sensitive in use. The obvious step was therefore for its place to be taken by a resilient structure. Via the intermediate stage of so-called O-ring butterfly valves, development continued to today’s profiled sealing rings. In these designs, the resilient sealing member is positioned on the disc and can be adapted in a variable way to the conditions at the seat in the body. There have also been further developments in the valve disc and in the mounting of the shafts in the body. The original lip seal has changed to O-ring seals held in cages of non-corroding material in this way. Also, the seals and shafts are now mounted in such a way as to be “blow-out-proof”.

2.3 Hydrants

As well as the changes to high-grade ductile materials for the bodies and to coatings preservative of both economic and operational value, there have also been changes in design as hydrants have developed. In hydrants of the old type, the valve cone providing the main shut-off was moved upwards, away from the pipe system, when the hydrant was opened. With a
change in the direction of movement to “downward-opening”, towards the pipe system, it was possible for the “double shut-off” function to be introduced. At the same time the material of the seal on the valve cones was changed from hide to elastomers.

In the field of underground hydrants, there was then a further innovation in the form of the introduction of one-piece bodies (Fig. 4). What had been used up to that point had been a flanged connection, in the ground, between the inlet piece to the body (which might have a double shut-off for example) and the body itself and the one-piece body meant that this was done away with. In the field of post hydrants (Fig. 5), the so-called "breakage point" was also introduced and the colour of the above-ground section was changed from gray to red.

2.4 Air-release and air-admission valves

Air-release and air-admission valves (Figs. 6 and 7) have followed the general trend that was apparent in engineering towards “smaller, lighter and higher performing”. Air-releasing and air-admitting performance was increased and at the same time the dimensions of the bodies, and hence their weights, were reduced thanks to high-grade ductile iron materials.

The latest development has produced what are known as “air-release and air-admission valve sets”. In these, the valve is supplied in a small pillar which is part of the valve. At the top end, the pillar ends in a street cap and thus even enables the valve itself to be stripped out for maintenance purposes by taking off the street cap.

2.5 Pressure and flow control valves

The broad class of pressure and flow control valves can be divided into the sub-class of needle valves (Figs. 8 and 9) and that of pressure reducing valves. In the sub-class of needle valves what can be considered a far-reaching innovation is the development that led to a piston, including the piston bearing, of stain-
less steel. The piston bearing is welded into the piston in this case. The purpose of this development was to ensure the long-term durability of the piston – even when operating with cavitation in the seat region.

Following the introduction of valves pilot-controlled by the medium itself, there was a shift in the sub-class of pressure reducing valves away from the spring-loaded valve to the pilot-controlled valve.

3 Resumé

There is a constant and continuous rise in the level of the requirements which components are called upon to meet in water supply. What components are mainly affected by in technical terms are the requirements arising from the construction of pipelines and the requirements arising from the operation of pipelines, particularly with regard to the quality of drinking water. Added to these nowadays are also more requirements for efficient and economical operation. There is a continuous increase in the pressure from outside for the efficiency of systems to be improved. Even though the proportion which components represent of the production costs of a pipeline system is at most 15%, they do have an effect on the overall costs if these are looked at holistically, i.e. in both technical and economic terms, which they do above all by ensuring long and damage-free use. The materials and components selected have to be matched to the particular field of use and the conditions which apply locally.

It is precisely in the case of large valves that the advantages of high-grade cast iron materials can be seen. After being in use for decades, needle valves of larger nominal widths can be remachined in the area of the seals and bearings. The cast iron body is preserved and in this way can achieve lifetimes of more than 50 years (see also the article beginning on page 49 of this issue of the journal).

References

[1] GSK Quality Association for the Heavy Duty Corrosion Protection of Powder Coated Valves and Fitting

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