

# Deviation between Theoretical Calculation and Practical Experiments of Pressure losses in Ball Valves

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**Abstract:** Pressure loss is an important criterion when designing and operating any pipeline system.

Theoretical calculation of pressure losses in 5 different types of ball valves gives an excellent prediction when designing pipeline system with 0.1- 0.3% deviation from experimental testing results.

In the test rig the factors affecting pressure loss were taken into accounts, in addition the type of flow was turbulent with Reynolds number ranging from more than 2400 to  $10^6$

**Keywords:** pipeline system. Theoretical Calculation, ball valves.

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## 1. INTRODUCTION

In most industrial and domestic networks ball shut off valves are usually dominant. The process of controlling the supply and distributing systems of water is laying upon these valves. Its known by default that Pressure losses occur in pipe networks because of friction, roughness and turbulent flow. In practice, the use of shut-off valves and fittings causes an increase in pressure losses due to changes in directions and it is considered an obstruction due to accumulation of dirt so, it's necessary to take these valves in account when designing pipe networks

### Test rig:

The designed unit can be used to investigate the pressure losses for various types of shut-off valves and fittings. The pipe elements used are commercially standard components in domestic and industrial networks. The clear panel is fixed on a sturdy, movable frame. It consists of five pipe sections, in each of which different shut-off valves and fittings are fixed properly. The pipe sections can be selected via ball valves individually. One of the pipe sections is transparent with a transparent ball valve to show the flow conditions upstream and downstream of a shut-off valve. The flow is controlled using valves in the inlet and outlet and record the reading on a rotameter. The pressure measuring points in the pipe networks are designed as annular chambers and are located directly upstream and downstream of the valves and fittings, ensuring a accurate pressure measurement. The sensors are connected in pairs to a differential pressure meter

Technical data for the component in test rig:

Electric differential pressure gauge with measuring ranges from 0-1200 mbar

Burst absolute pressure maximum equal 7 bar

Differential pressure range -1, +5 bar

Float flowmeters range from 0 -1800 l/h

### Object measured:

PVC DN 32 Ball valve, with internal diameter 32 mm

Resistance Coefficient  $\xi = 0$

Ms galvanized Ball valve DN 15 with internal diameter = 15 mm

Resistance Coefficient  $\xi = 0$

Stanted seat valve DN15 with internal diameter= 18 mm

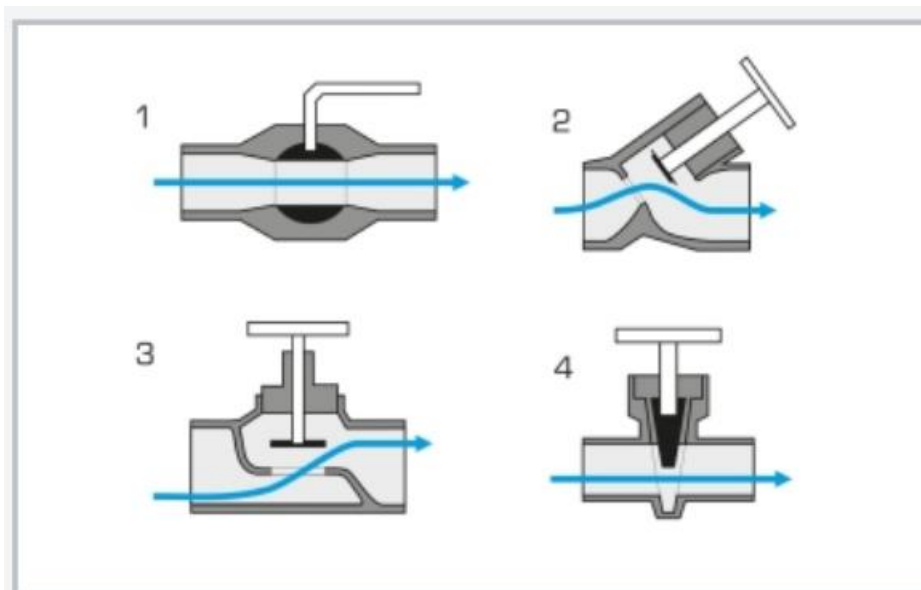
Resistance Coefficient  $\xi = 3$

Straight seat valve DN 15 with internal diameter 17mm

Resistance Coefficient  $\xi = 10$

Socket shut-off gate valve DN15 with internal diameter 15 mm

Resistance Coefficient  $\xi = 1$



2. RESULTS

Wall roughness		
Material	Surface	Wall roughness k
Ball valve PVC transparent	Technical smooth	0.001 mm
Ms galvanized Ball valve	Technical smooth	0.001 mm
In – line Slanted seat valve	Technical smooth	0.001 mm
In line Straight seat valve	Technical smooth	0.001 mm
Socket shut off gate valve	Technical smooth	0.001 mm

Kinematic viscosity ( $\nu$ ) of water at temperature = 30 C=  $0.801 \cdot 10^{-6}$  m<sup>2</sup>/s.

**Performing the experiment:**

The network is designed to perform one object being tested at any time when the other being off service.

The volumetric flow meter measures the flow rate by l/h.

Measured results PVC transparent DN32 Ball valve L=240 mm		Calculate results
Volumetric flow rate $\dot{v}$ in L/hr.	$p_v$ in mbar	$p_v$ in mbar
220	0	0.002
420	0	0.0021
620	0	0.00223
820	0	0.00247
1020	0	0.00265
1220	0	0.00287

Measured results Ms offs. DN15 Ball Valve L=220 mm		Calculate results
Volumetric flow rate $\dot{v}$ in L/hr.	$p_v$ in mbar	$p_v$ in mbar
220	0	0.003
420	0	0.0032
620	2	2.1
820	7	7.1
1020	10	10
1220	16	16.3

Measured results In line valve DN15 Slanted seat L=250 mm		Calculate results
Volumetric flow rate $\dot{v}$ in L/hr.	$p_v$ in mbar	$p_v$ in mbar
220	0	0.3
420	3	3.5
620	12	12.8
820	23	22.5
1020	38	38
1220	57	58

Measured results in line valve DN15 Straight seat L=220 mm		Calculate results
Volumetric flow rate $\dot{v}$ in L/hr.	$p_v$ in mbar	$p_v$ in mbar
220	4	4.1
420	26	27
620	61	60.5
820	111	107
1020	185	187
1220	254	259

Measured results Socket shut off gate valve DN15 L=180 mm		Calculate results
Volumetric flow rate $\dot{v}$ in l/hr	$p_v$ in mbar	$p_v$ in mbar
220	0	0.003
420	0	0.0032
620	3	3.12
820	7	7.08
1020	14	14.3
1220	22	22.91

Volumetric flow rate $\dot{v}$ in l/hr	Ball valve PVC transparent DN32 L=240 mm	Ball Valve Ms offs. DN15 L=220 mm	Stanted seat in line valve DN15 L=250 mm	Straight seat in line valve DN15 L=220 mm	Socket shut off gate valve DN15 L=180 mm
220	0	0	0	4	0
420	0	0	3	26	0
620	0	2	12	61	3
820	0	7	23	111	7
1020	0	10	38	185	14
1220	0	16	57	254	22

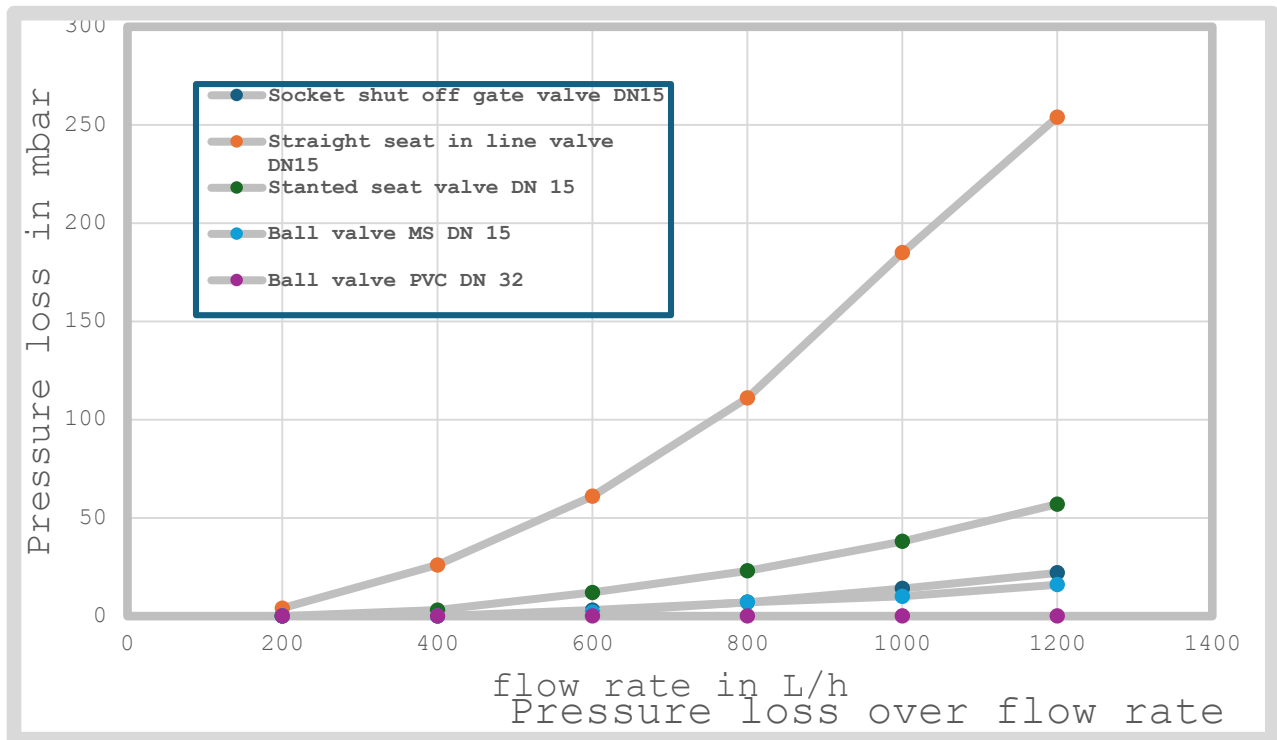


Figure 1: Experimental results Pressure Loss vs Flow Rate

**Calculation of coefficients of resistance**

For shut off ball valve, started seat valve and gate valve the coefficient of resistance is determined according to the following formula:

$$\xi = \frac{p_v}{\rho v^2} - \lambda \frac{L}{D}$$

Where:

$\xi$  is the coefficient of resistance

$\lambda$  is coefficient of friction

$v$  is speed in m/s

$p_v$  is pressure loss in N/m<sup>2</sup>

L is the pipe length in m or mm

D is the pipe diameter in m or mm

$\rho$  is the density in kg/m<sup>3</sup>

Calculation of coefficient of resistance for various ball valves, valve and gate						
Pipe section	Internal diameter D in mm	Length in mm	Volumetric flow	Flow speed in m/s	Reynolds No. Re	d/k
1 ball valve Dn 32	32	240	33.3*10 <sup>-5</sup>	0.41	12159	32000
2 ball valve DN 15	15	220	33.3*10 <sup>-5</sup>	1.88	28135	15000
3 slanted seat valve DN 15	18	250	33.3*10 <sup>-5</sup>	1.31	21853	18000
4 straight seat valve DN 15	17	220	33.3*10 <sup>-5</sup>	1.47	23160	17000
5 socket gate valve DN 15	15	180	33.3*10 <sup>-5</sup>	1.88	30241	15000

Pipe section	$\lambda$ Calculation according to	$\lambda$ Pipe friction Coefficient	$p_v$ Calculated pressure loss in mbar	$\xi$ Coefficient of resistance
Ball valve DN 32	Blasius	0.001	11	0.0579
Ball valve DN 15	Blasius	0.0249	17	0.12
Slanted seat valve DN15	Blasius	0.0260	57	2.96
Straight seat valve DN 15	Blasius	0.0256	254	11.40
Socket gate valve DN 15	Blasius	0.0286	25	0.36

The graphic representation of measurements and calculation results show that the straight seat valve have a highest loss where the ball valve DN32 have lowest losses and gate valve also have little losses than slanted one.

**Results: Pressure Loss and Coefficient of Resistance**

**Table 1: Volumetric Flow Rate vs Pressure Loss**

Flow Rate (l/h)	Ball Valve DN32 (mbar)	Ball Valve DN15 (mbar)	Slanted Seat Valve (mbar)	Straight Seat Valve (mbar)	Gate Valve (mbar)
220	0	0	3	4	0
420	0	0	12	26	0
620	0	2	23	61	3
820	0	7	38	111	7
1020	0	10	57	185	14
1220	0	16	57	254	22

Valve Type	Coefficient of Resistance ( $\zeta$ )
Ball Valve DN32	0.0579
Ball Valve DN15	0.12
Slanted Seat Valve	2.96
Straight Seat Valve	11.40
Gate Valve	0.36

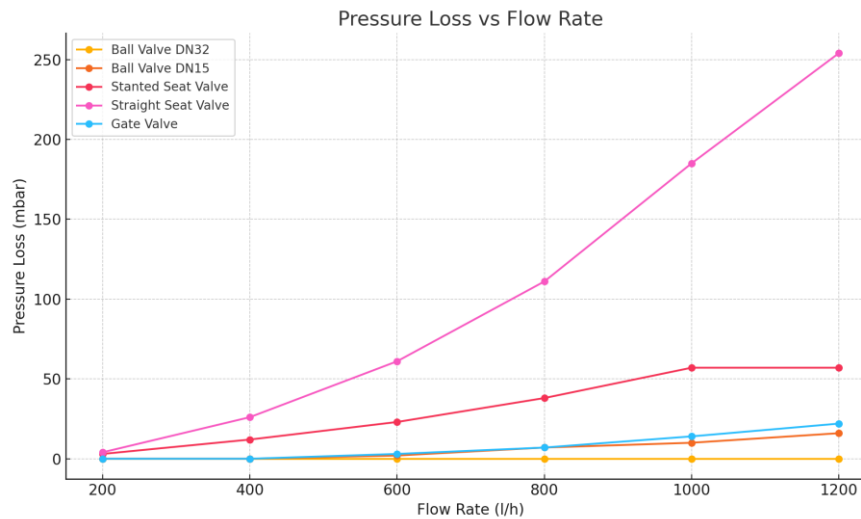


Figure 2: Calculated results Pressure Loss vs Flow Rate

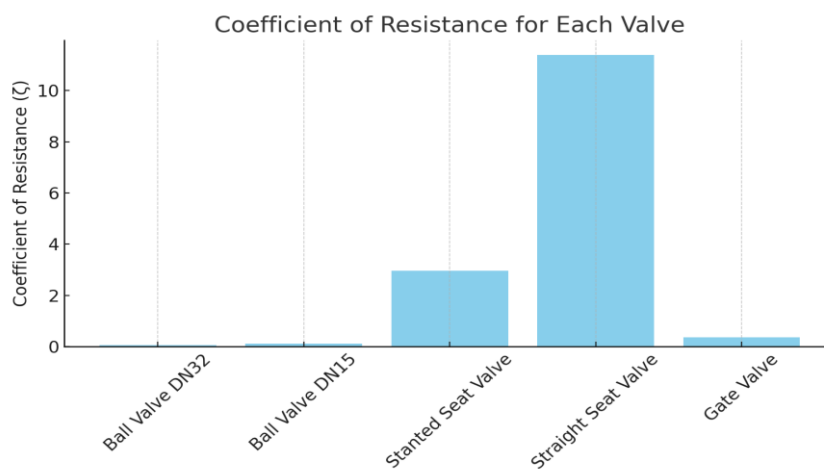


Figure 3: Calculated Coefficient of Resistance for Each Valve

### 3. RECOMMENDATIONS

Its preferable to use ball valve and gate valve and little depend upon the straight seat valve as possible,

### REFERENCES

- [1] Çengel, Yunus A., and John M. Cimbala. Fluid Mechanics: Fundamentals and Applications. McGraw-Hill Education, 2014.
- [2] Munson, Bruce R., Donald F. Young, and Theodore H. Okiishi. Fundamentals of Fluid Mechanics. Wiley, 2013.
- [3] Idel'chik, I. E. Handbook of Hydraulic Resistance. CRC Press, 1994.
- [4] Fox, Robert W., Alan T. McDonald, and Philip J. Pritchard. Introduction to Fluid Mechanics. Wiley, 2011.
- [5] Darby, Ron. Chemical Engineering Fluid Mechanics. CRC Press, 2016.