FLOW CALCULATOR

Design Programs for EBRO Butterfly Valves

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Client: EBRO-ARMATUREN Gebr. Bröer GmbH, Hagen

Inhalt

1 Symbols and Nomenclature

Symbol	Nomenclature	Unit
D	Inside diameter of the pipe	mm
DN	Nominal Diameter of the butterfly valve	-
DN_{Lmin}	Minimum diameter of the pipe	-
F_P	Pipe geometry factor	-
F_R	Reynolds number factor	-
κ	adiabatic exponent	-
Kav	Measure for Kavitation, Kav x_F/z_y	-
K_V	Flow coefficient	m^3/h
L_A	Sound pressure level at distance of 1m	dB(A)
p_1	Pressure upstream of butterfly valve	bar_{abs}
p_C	Thermodynamical critical pressure	bar_{abs}
p_N	Normal pressure 1,013 bar_{abs}	bar_{abs}
PN	Nominal pressure	bar
p_V	Boiling pressure	bar
Q_1	Volume flow rate at operating condition p_1 and t_1 upstream of the butterfly valve	m^3/h
Q_N	Volume flow rate at normal condition p_1 and t_N	m^3/h
Re_V	Butterfly valve Reynolds number	-
T	Temperature	°C
t_1	Temperature upstream of the butterfly valve	°C
t_N	Normal temperature 0°C	°C
V	Velocity in the pipe (with fluids)	m/s
V_K	Velocity in the throttling area (with fluids)	m/s
V_1	Velocity in the pipe upstream of the butterfly valve (with gas/steam)	m/s
V_2	Velocity in the pipe downstream of the butterfly valve (with gas/steam)	m/s
W	Mass flow rate	kg/h
x_F	Pressure ratio with fluids	-
Y	Expansion factor	-
z_y	x_F-value at start of cavitation (depends on α)	-
α	(Opening-) angle of butterfly valve plate	°
ΔL_F	Butterfly valve specific correction element with fluids	dB(A)
Δp	Pressure loss of the butterfly valve	bar
Δp_L	Pressure loss of the pipe	bar
Δp_{ges}	Pressure loss of the butterfly valve and the pipe together	bar
η	Dynamic viscosity	Pa s
λ	Coefficient of friction, depends on Reynolds number and roughness of pipe	-
ρ	Density	kg/m^3
ρ_1	Density at operating condition p_1 and t_1 upstream of the butterfly valve	kg/m^3
ρ_N	Density at normal condition p_N and t_N	kg/m^3

2 Summary

The Program is constructed with the Software EXCEL used to calculate flow- and sonically dimensions for compressible and incompressible fluids on the basis of the rules and standards [1] to [5] and on the basis of theoretical analysis [6] and [18]. Butterfly valves and substance-specific data are taken from the sources [7] to [17].

Important!	This program works with Macros. To use the Macro they have to be allowed in Excel. If the Macros weren't allowed, the program doesn't work!

(Macros can only be used when the security level is minimum selected:
Office 2007: „Deactivate all Macros with message"
Office 2003: „Security Level medium/middle"
with these settings the Macros have to be activated every time the program will be opened.)

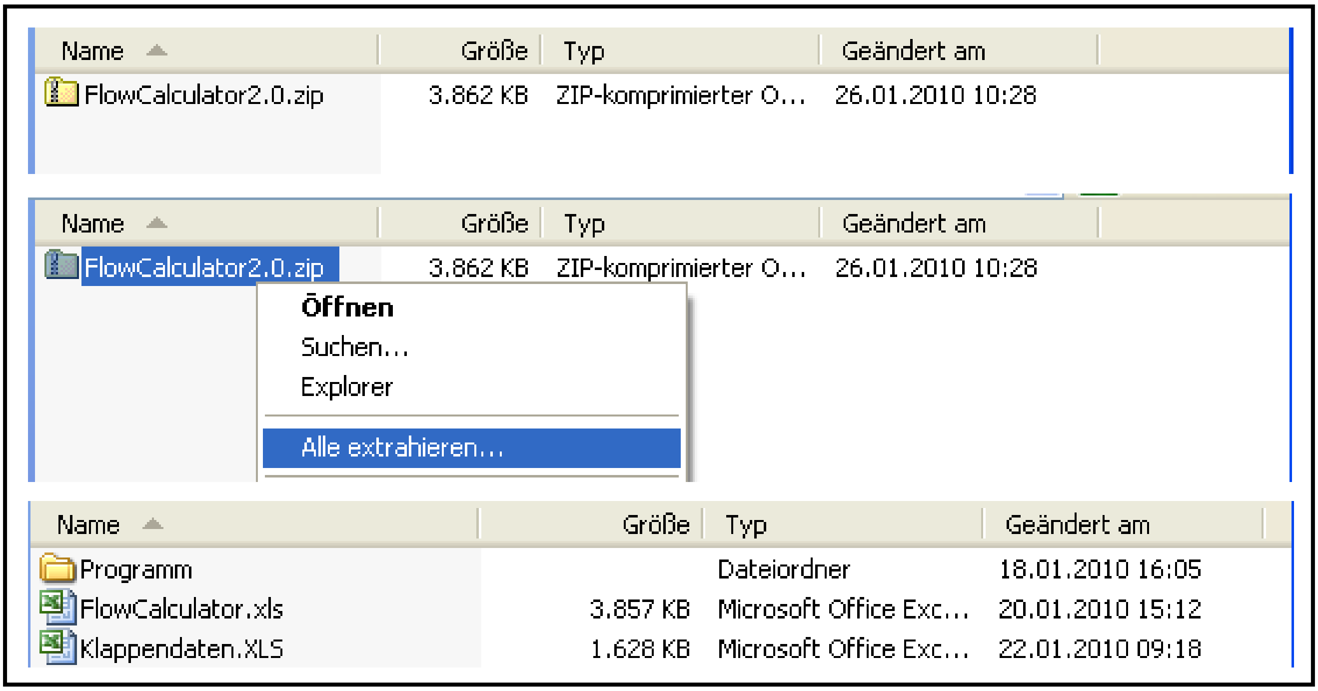
3 Installation

Extract the „FlowCalculator.zip“ (e.g. mit Winzip). Memory Location of the program can be selected (for example „c:\“). In the file folder folder „Flow Calculator“ is a file named „Flow Calculator.xls“. Opening this file will open the program (Chapter 4.2).

Don’t change the structure of the file folder „Flow Calculator“!

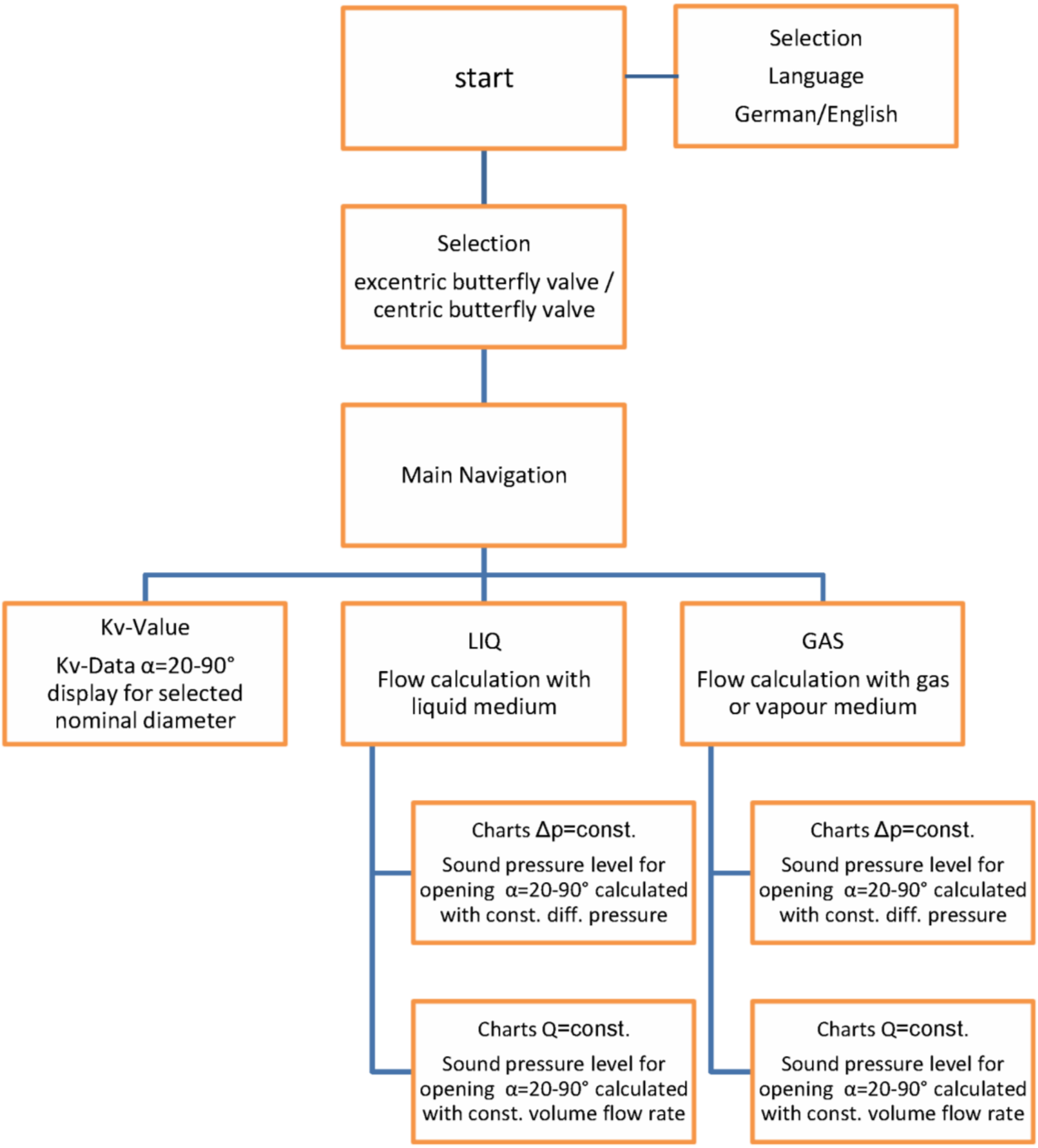
Abstract:

Flow Calculator.zip	extract
Double-click on Flow Calculator	open program



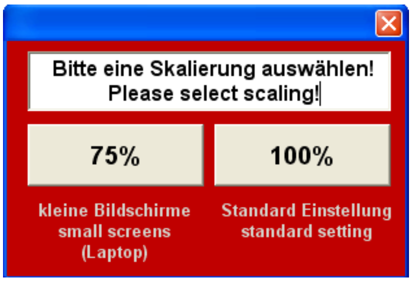
4 Program, Menu, Input

4.1 Program structure



4.2 Start page

4.2.1 Scale

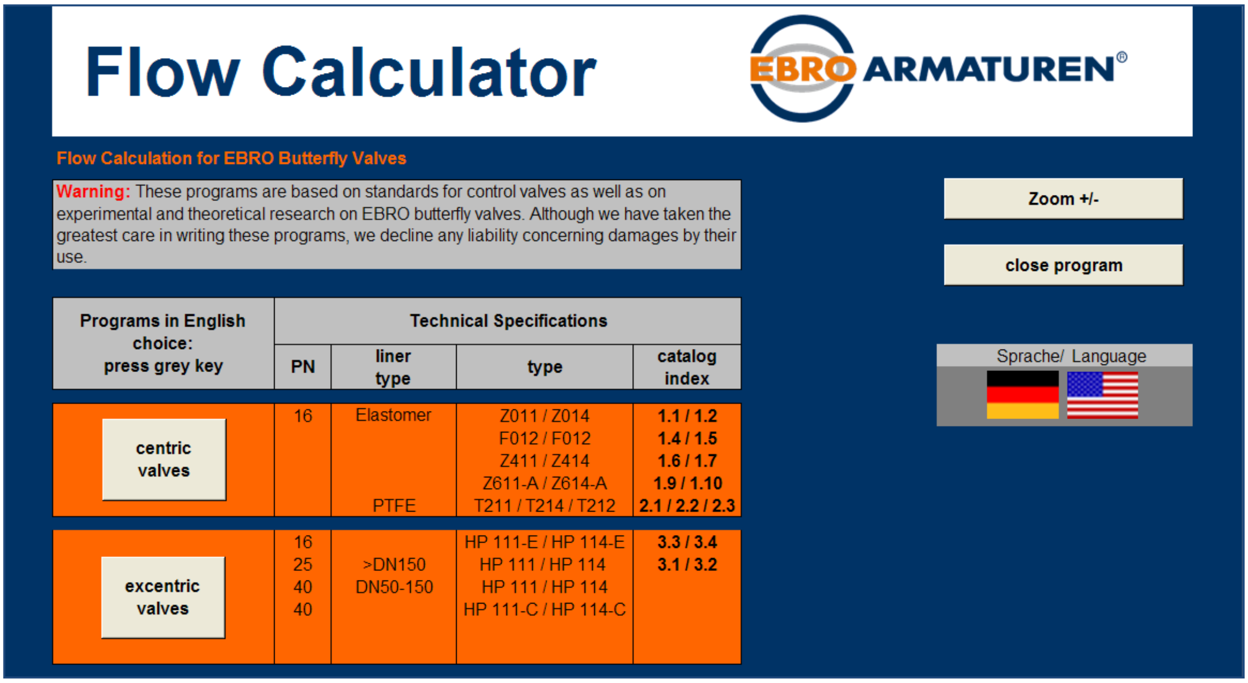


This choice box for scale of the excel-sheets will be first on the start page when the macros are activated. The scale of 75% is possible for using the program at laptop (with smaller screen). The display of the flow calculator will be reduced to 75%. With this scale scrolling of the sheets during using the program will be reduced.

The scale of 100% is suited for PC's with normal screens.

4.2.2 Start page

When you select a scale, you can see the start page:



At the right side of the page the following program options can be select:

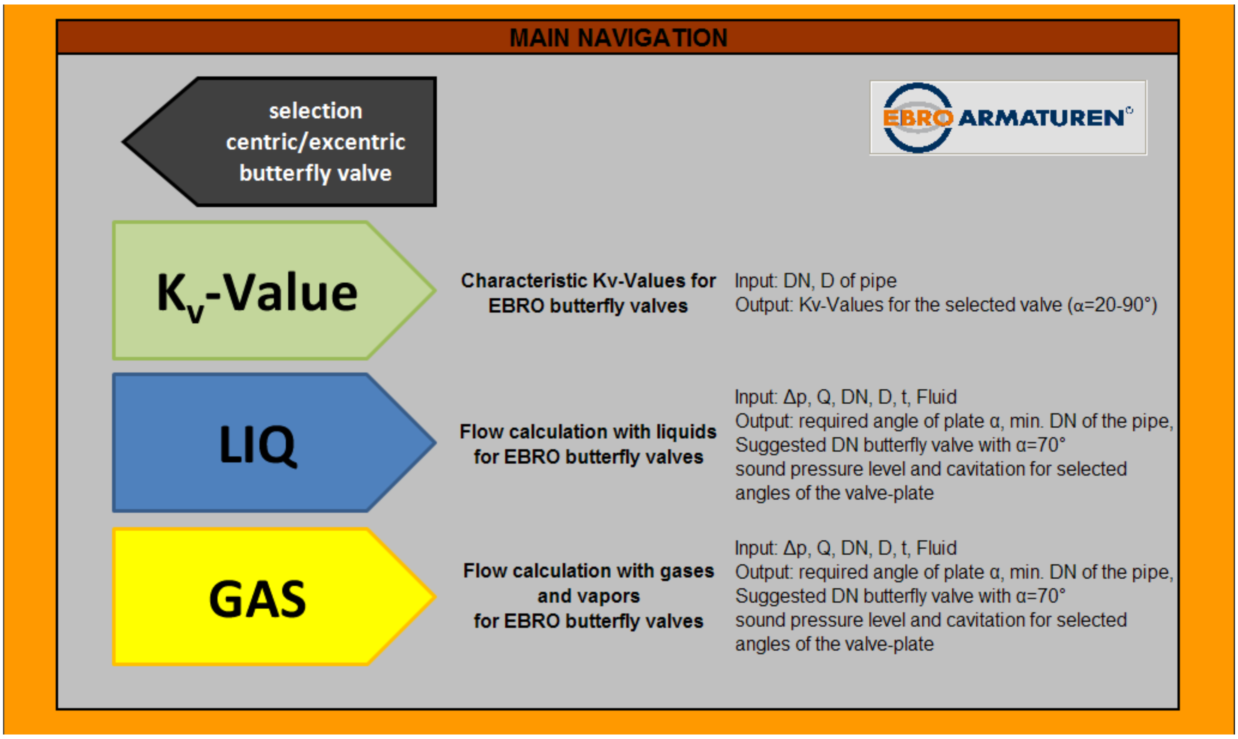
[Zoom +/-]:	The scale (Chapter 4.2.1) can be change every time.
[Close program]:	Closes the program.
[Sprache/Language]:	The menu navigation switch to English or German by click on the flag.

The type of butterfly valve can be selected on the left side of the page. With the grey buttons the types [centric valves] or [excentric valves] can be selected. The table right beside the grey buttons informs with which types of butterfly valves you can calculate after choosing a butterfly valve type. It also informs which nominal pressure they have, which type of liner they have and in which register of the EBRO-Catalogue the types are.

Below this table is the information of the Author and Client, as well as this documentation of the program which can be opened by a click on the grey button [documentation].

4.3 Calculation centric/ecxentric butterfly valves

This page “Main navigation” follows by selecting a type of butterfly valve (Chapter 4.2). From this page there are labeled arrows which leads you through the program. Generally the left-pointing arrows take you back to the previous page. The right-pointing arrows take you to the next page.



Left-pointing arrow:

- „selection centric/excentric butterfly valve“:

  By a click on this arrow you can get back to the starting page (Chapter 4.2)

Right-pointing arrows:

- K_v-Value (Chapter 4.4)

  Fluid-independent calculation of K_v-values for butterfly valve types
- FLÜ (Chapter 4.5)

  Calculation of flow data for butterfly valves for liquid fluids
- GAS (Chapter 4.6)

  Calculation of flow data for butterfly valves for gases and steam

4.4 Calculation Kv-value centric/excentric butterfly valves

The Calculation of the K_v-Value is Fluid-independent.

The following data have to be entered for Calculation:

1. EBRO Type [Selection]

   The EBRO Type can be selected dependent on the selected type at the start page (Chapter 4.2).

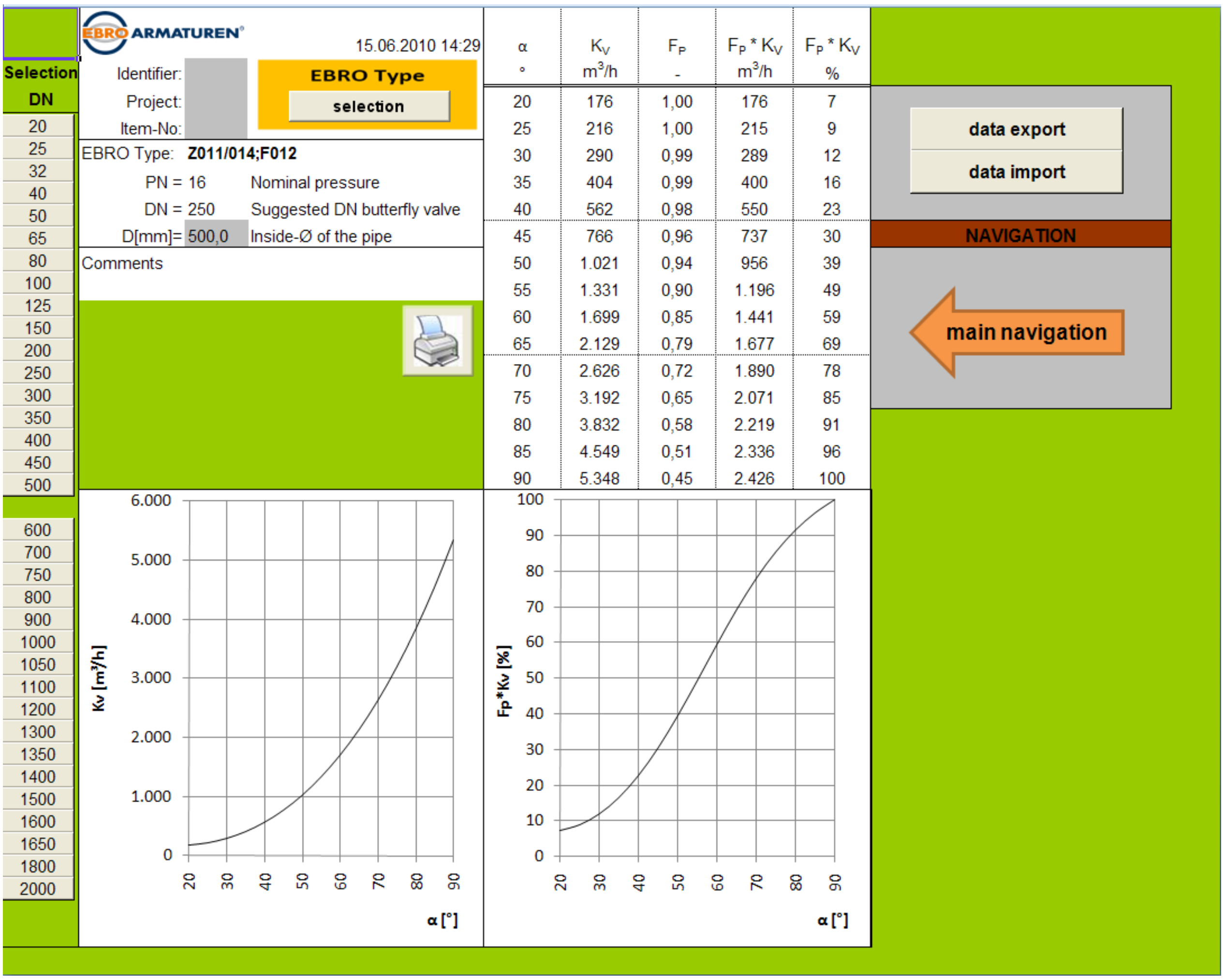
   →When "centric valve" is selected then the standard EBRO-Type is Z011/014; F012. With the [selection]-Button the valve type can be changed to EBRO-Type T200 and also back to Z011/014; F012. When the type is changed to T200, you must choose between the EBRO-Types T200-A metallic, T200-C metallic, T200-A PTFE (coated disc) and T200-C PTFE (coated disc).

   →When "excentric valve" is selected then the standard EBRO-Type is HP111/114. With the [selection]-Button the valve type can be changed to EBRO-Type HP111/114-E and HP111/114-C and also back to HP111/114.
2. With the buttons on the left side of the page the nominal size DN of the valve type can be selected. There are only the DN's displayed which are available for the selected valve type.
3. The inside Diameter D of the pipe. The inside Diameter of the pipe should not be less than the nominal size of the selected valve. When DN is bigger than D the message "DN>D"is displayed (Chapter 5).

Output data:

When the Input data are complete entered, the K_v-value of the butterfly valve for an opening angle from α=20°-90° is displayed graphically (diagram on the left side) and tabular.

If the inside diameter D of the pipe is greater than the DN of the butterfly valve, the Kv-value will be smaller because of the difference between the pipe and the valve. The factor F_P shows this influence. The factor is shown in the table and the calculated K_v-value. The right diagram shows the K_v-value calculated with the factor F_P*K_v.



α °	K_V m^3/h	F_P -	$F_P * K_V$ m^3/h	$F_P * K_V$ %
20	176	1,00	176	7
25	216	1,00	215	9
30	290	0,99	289	12
35	404	0,99	400	16
40	562	0,98	550	23
45	766	0,96	737	30
50	1.021	0,94	956	39
55	1.331	0,90	1.196	49
60	1.699	0,85	1.441	59
65	2.129	0,79	1.677	69
70	2.626	0,72	1.890	78
75	3.192	0,65	2.071	85
80	3.832	0,58	2.219	91
85	4.549	0,51	2.336	96
90	5.348	0,45	2.426	100

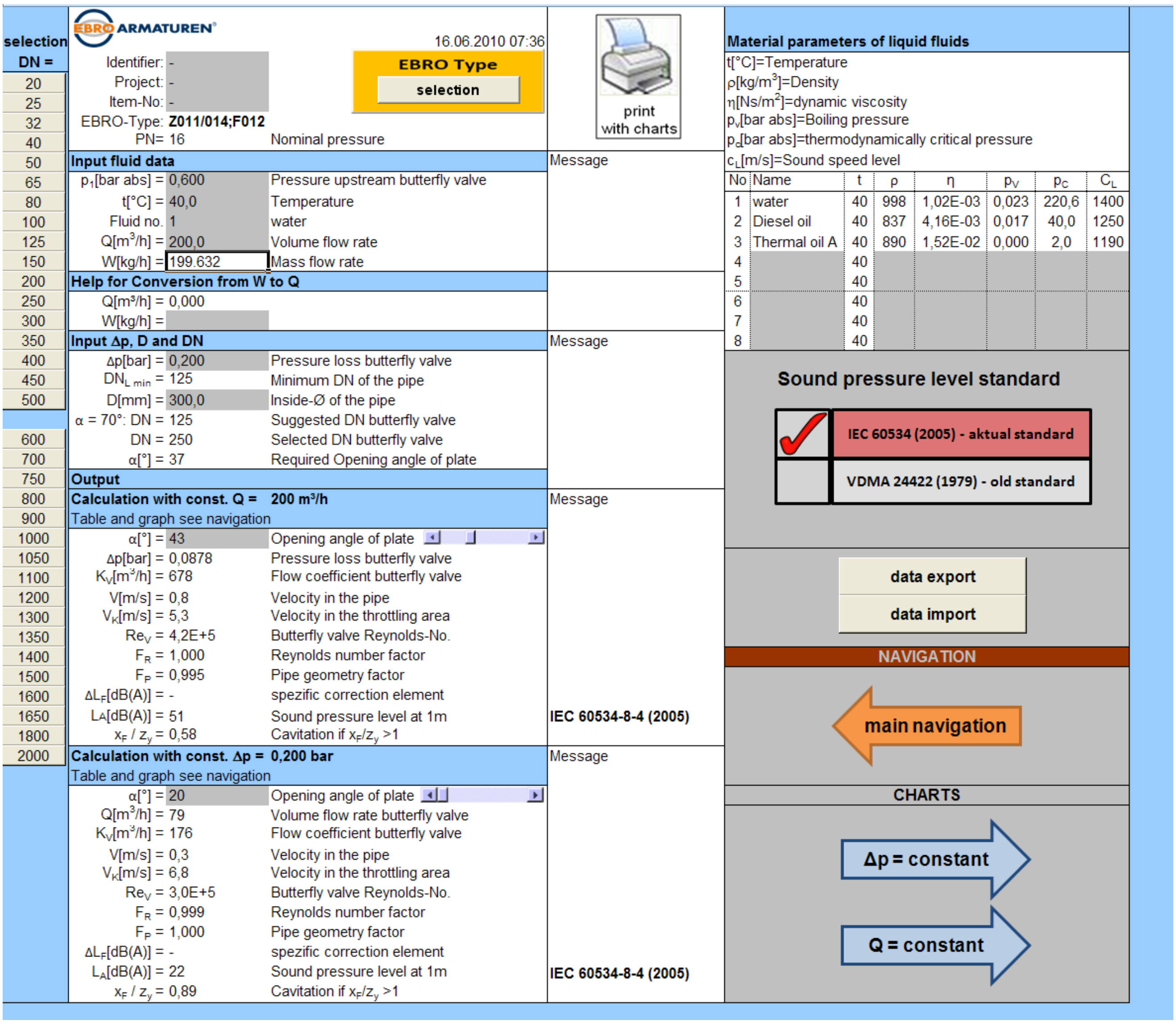
4.5 Calculation of flow data for butterfly valves for liquid fluids

The following data have to be entered for Calculation:

1. EBRO Type [selection] (Description see Chapter 4.4)
2. With the buttons on the left side of the page the nominal size DN of the valve type can be selected. There are only the DN's displayed which are available for the selected valve type.
3. The pressurep_1 in bar abs upstream the butterfly valve.
4. The temperature t of the fluid.
5. The fluid. Here a Fluid No. has to be entered. The Fluid-No. for the fluids can be selected from the table of the right side. The material data ρ, η, p_v and p_c of the fluids No. 1 to 3 will be calculated after the input of the temperature t. For other fluids the material data of the fluids have to be entered in the table (possible in the grey areas).
6. The volume flow rate Q in m³/h – when a mass flow rate in kg/h is given, the volume flow rate can be calculated with the "Help for Conversion from W to Q". For this calculation the temperature and the Fluid-No. have to be entered.
7. The pressure loss of the butterfly valve $\Delta p = p_2 - p_1$.
8. The inside Diameter D of the pipe. The inside Diameter of the pipe should not be less than the nominal size of the selected valve. When DN is bigger than D the message „DN > D"is displayed (Chapter 5).

Output data:

- „Input Δp, DN and D"
  DN_{Lmin}: The minimum nominal size of the pipe depending on the input data.
  α = 70°: DN: nominal size of the butterfly valve with an opening angle of α =70° depending on the input data
  DN: selected nominal size of the butterfly valve
  α[°]: Required opening angle for the selected butterfly valve depending on the input data.
- „Calculation with const. Q"
  Calculation of Δp, K_v, V, V_K, Re_V, F_R, F_P and the sound pressure level with the cavitation factor x_F/z_y depending on the input volume flow rate Q. The pressure loss of the butterfly valve depends on the selected opening angle α (which you can enter in the grey area or select by scroll bar).
- „Calculation with const. Δp"
  Calculation of Q, K_v, V, V_K, Re_V, F_R, F_P and the sound pressure level with the cavitation factor x_F/z_y depending on the input pressure loss of the butterfly valve Δp. The Volume flow rate Q depends on the selected opening angle α (which you can enter in the grey area or select by scroll bar).



<u>Navigation menu at the right side of the page:</u>

Click on the orange left-pointing arrow to get back to the “main navigation“(Chapter 4.3) where you can select the calculation method: K_v-value, FLÜ and GAS.

The two right-pointing arrows lead you to the pages with tables and diagrams.

<u>Arrow labeled “Δp = constant“:</u> A sheet where you can see a table with flow data calculated depending on the input data for the selected valve and opening angle from α = 20° to 90°. The calculation depends on the pressure loss of the valve Δp from the input data, the volume flow rate Q is changing depending on the opening angle α. The last row shows the optimal opening angle for the specified Δp.

<u>Arrow labeled “Q = constant”:</u> The same like the “Δp = constant” but the calculation depends on the given volume flow rate with the pressure loss of the valve Δp depends on the opening angle α.

The last row shows the optimal opening angle for the specified Q.

Sheet with “Δp = constant”:

EBRO ARMATUREN® 16.06.2010 07:36

Identifier: -
Project: -
Item-No: -
EBRO-Type: **Z011/014;F012**

PN= 16	Nominal pressure
DN= 250	Selected DN butterfly valve
D[mm] = 300,0	Inside-Ø of pipe
p_1[bar abs] = 0,600	Pressure upstream butterfly v.
t[°C] = 40,0	Temperature
Fluid = water	
ρ[kg/m³] = 998	Density
η[Ns/m²] = 0,001021	dynamic viscosity
p_V[bar abs] = 0,023	Boiling pressure
p_C[bar abs] = 220,6	thermodyn. critical pressure
Q[m³/h] = 200,0	100% volume flow rate
W[kg/h] = 199.632	100% mass flow rate
Δp[bar] = 0,2000	Pressure loss butterfly valve

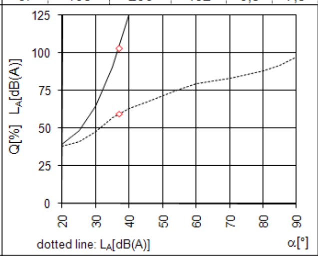
α	Q	Q	K_V	V	V_K	Re_V	F_R	F_P	X_F / z_y	L_A	$ΔL_F$
°	%	m³/h	m³/h	m/s	m/s	-	-	-	-	dB(A)	dB(A)
20	39	79	176	0,3	6,8	3,0E+5	0,999	1,000	0,89	38	-
25	48	96	216	0,4	6,9	3,3E+5	1,000	0,999	0,97	41	-
30	65	130	290	0,5	7,1	3,9E+5	1,000	0,999	1,06	48	-
35	90	181	404	0,7	7,3	4,7E+5	1,000	0,998	1,15	57	-
40	125	250	562	1,0	7,7	5,7E+5	1,000	0,996	1,26	63	-
45	170	340	766	1,3	8,2	6,9E+5	1,000	0,993	1,37	68	-
50	226	452	1021	1,8	8,8	8,2E+5	1,000	0,989	1,50	72	-
55	292	584	1331	2,3	9,5	9,7E+5	1,000	0,981	1,66	76	-
60	363	725	1699	2,9	10,1	1,1E+6	1,000	0,969	1,84	79	-
65	410	821	2129	3,2	10,1	1,2E+6	1,000	0,953	2,06	81	-
70	455	910	2626	3,6	10,0	1,2E+6	1,000	0,931	2,35	83	-
75	496	991	3192	3,9	10,0	1,3E+6	1,000	0,902	2,75	85	-
80	534	1067	3832	4,2	10,0	1,3E+6	1,000	0,867	3,35	88	-
85	571	1142	4549	4,5	10,0	1,4E+6	1,000	0,827	4,37	92	-
90	610	1220	5348	4,8	10,1	1,4E+6	1,000	0,781	6,50	98	-
37	103	206	462	0,8	7,5	5,1E+5	1,000	0,998	1,19	60	-

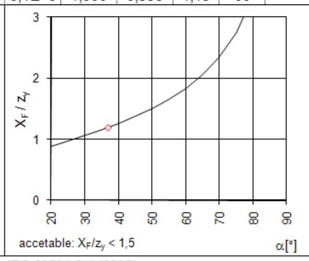
NAVIGATION

Input Data

CHARTS

Q = constant





Sound pressure level calculated according to IEC 60534-8-4 (2005)

Sheet with “Q = constant”:

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Identifier: -
Project -
Item-No: -
EBRO-Type: **Z011/014;F012**

PN= 16	Nominal pressure
DN= 250	Selected DN butterfly valve
D[mm] = 300,0	Inside-Ø of the pipe
p_1[bar abs] = 0,600	Pressure upstream butterfly v.
t[°C] = 40,0	Temperature
Fluid = water	
ρ[kg/m³] = 998	density
η[Ns/m²] = 0,001021	dynamic viscosity
p_V[bar abs] = 0,023	Boiling pressure
p_C[bar abs] = 220,6	thermodyn. critical pressure
Q[m³/h] = 200,0	Volume flow rate
W[kg/h] = 199.632	Mass flow rate
Δp[bar] = 0,2000	100% Pressure loss butterfly v.

α	Δp	Δp	K_V	V	V_K	Re_V	F_R	F_P	X_F / z_y	L_A	$ΔL_F$
°	%	bar	m³/h	m/s	m/s	-	-	-	-	dB(A)	dB(A)
20	#NV	#NV	176	#NV	#NV	#NV	#NV	1,000	#NV	#NV	-
25	#NV	#NV	216	#NV	#NV	#NV	#NV	0,999	#NV	#NV	-
30	#NV	#NV	290	#NV	#NV	#NV	#NV	0,999	#NV	#NV	-
35	123	0,245	404	0,8	8,1	5,2E+5	1,000	0,998	1,41	71	-
40	64	0,128	562	0,8	6,2	4,6E+5	1,000	0,996	0,80	54	-
45	35	0,069	766	0,8	4,8	4,0E+5	1,000	0,993	0,47	50	-
50	20	0,039	1021	0,8	3,9	3,6E+5	1,000	0,989	0,30	47	-
55	12	0,023	1331	0,8	3,3	3,3E+5	1,000	0,981	0,19	44	-
60	7	0,015	1699	0,8	2,8	3,1E+5	0,999	0,969	0,14	41	-
65	5	0,010	2129	0,8	2,5	2,9E+5	0,999	0,953	0,10	39	-
70	3	0,007	2626	0,8	2,2	2,7E+5	0,999	0,931	0,08	37	-
75	2	0,005	3192	0,8	2,0	2,6E+5	0,999	0,902	0,07	36	-
80	2	0,004	3832	0,8	1,9	2,5E+5	0,999	0,867	0,06	34	-
85	1	0,003	4549	0,8	1,8	2,4E+5	0,999	0,827	0,06	34	-
90	1	0,002	5348	0,8	1,7	2,4E+5	0,999	0,781	0,07	33	-
37	94	0,188	462	0,8	7,3	5,0E+5	1,000	0,998	1,12	61	-

NAVIGATION

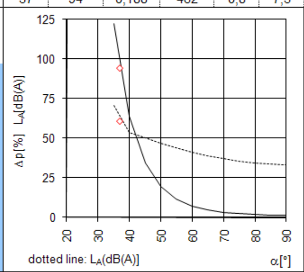
Input Data

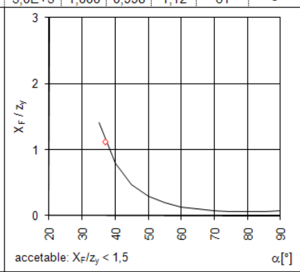
CHARTS

Δp = constant

Comments:

Sound pressure level calculated according to IEC 60534-8-4 (2005)





4.6 Calculation of flow data for butterfly valves for gas and vapor

The following data have to be entered for Calculation:

1. EBRO Type [selection] (Description see Chapter 4.4)
2. With the buttons on the left side of the page the nominal size DN of the valve type can be selected. There are only the DN's displayed which are available for the selected valve type.
3. The pressurep_1 in bar abs upstream the butterfly valve.
4. The temperature t_1 of the fluid. (t_1 < 180°C)
5. The fluid. Here a Fluid No. has to be entered. The Fluid-No. for the fluids can be selected from the table of the right side. The material data ρ_N, κ, and the molar mass M of the gas/vapor No. 1 to 35 are given.

   ➔ **DETAILS FOR ENTERING A NEW GAS**

   For other fluids the material data of the fluids have to be entered in the table (possible in the grey areas). For this case you have to take care about these things:

- The molar mass M which is important for the calculation of the sound pressure level. When you can't find out the molar mass from the new gas, then you can change the calculation of the sound pressure level from IEC 60534 to VDMA 24422 (Chapter 7). The calculation with the VDMA doesn't need the molar mass to calculate the sound pressure level.
- The density ρ_N at normal condition isn't given; you can calculate it by using the operating conditions p_1 and t_1. Enter the pressure p_1 and temperature t_1 at operating condition and then enter ρ_1 in the grey area of the "Help for conversion from ρ_1 to ρ_N" and the density ρ_N at normal condition will be calculated. These density can now be entered for the new gas in the table for Fluids and the calculation of the other parameters can be done. (Apply in case of doubt, particularly in case of a high pressure p_1 and a low temperature t_1.)
- If the adiabatic exponent κ of the gas isn't given, an adiabatic exponent of κ = 1,3 is applicable for the most cases.

6. The volume flow rate for normal condition Q_N in m³/h. When a mass flow rate in kg/h in given, the volume flow rate can be calculated with the "Help for Conversion from W to Q" in the volume flow rate. In this "Help for Conversion from W to Q" you also can convert a Volume flow rate Q_1 or mass flow rate W at operating condition in a volume flow rate Q_N at normal condition. For this calculation the temperature t_1 and the Fluid-No. have to be entered before.
7. The pressure loss of the butterfly valve $\Delta p = p_2 - p_1$.
8. The inside Diameter D of the pipe. The inside Diameter of the pipe should not be less than the nominal size of the selected valve. When DN is bigger than D the message „DN > D" is displayed (Chapter 5).

Output data:

- „Input Δp, DN and D"

  DN_{Lmin}: The minimum nominal size of the pipe depending on the input data.

  α = 70°: DN: nominal size of the butterfly valve with an opening angle of α =70° depending on the input data

  DN: selected nominal size of the butterfly valve

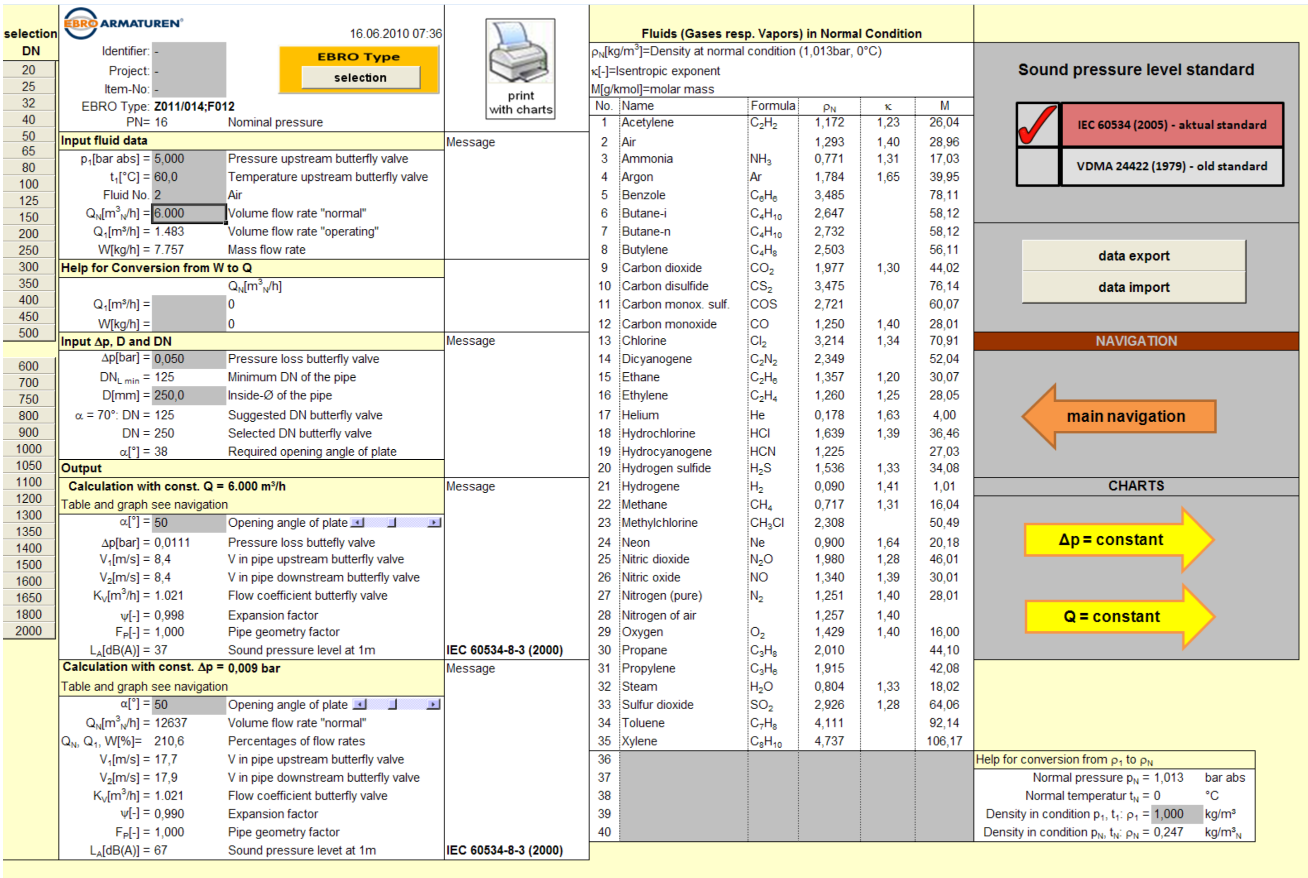
  α[°]: Required opening angle for the selected butterfly valve depending on the input data.

- „Calculation with const. Q"

  Calculation of Δp, V1, V2, K_v, ψ, F_P and the sound pressure level L_A depending on the input volume flow rate Q. The pressure loss of the butterfly valve depends on the selected opening angle α (which you can enter in the grey area or select by scroll bar).

- „Calculation with const. Δp"

  Calculation of Q, V1, V2, K_v, ψ, F_P and the sound pressure level L_A depending the input pressure loss of the butterfly valve Δp. The Volume flow rate Q depends on the selected opening angle α (which you can enter in the grey area or select by scroll bar).



Navigation menu at the right side of the page:

Click on the orange left-pointing arrow to get back to the “main navigation“(Chapter 4.3) where you can select the calculation methods: K_v-value, FLÜ and GAS.

The two right-pointing arrows lead you to the pages with tables and diagrams.

Arrow labeled “Δp = constant“: A sheet where you can see a table with flow data calculated depending the input data for the selected valve and opening angle from α = 20° to 90°. The calculation depends on the pressure loss of the valve Δp from the input data, the volume flow rate Q is changing depending on the opening angle α. The last row shows the optimal opening angle for the specified Δp.

Arrow labeled “Q = constant”: The same like the “Δp = constant” but the calculation depends on the given volume flow rate with the pressure loss of the valve Δp depending on the opening angle α.

The last row shows the optimal opening angle for the specified Q.

Sheet with “Δp = constant“:

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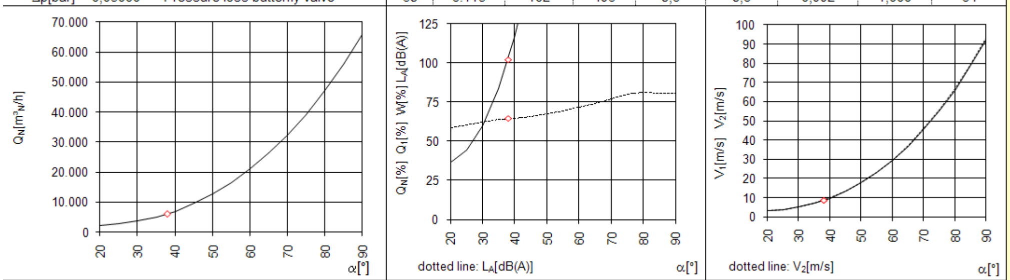
Identifier: -
Project: -
Intem-No: -
EBRO-Type: **Z011/014;F012**

PN= 16	Nominal pressure
DN = 250	Selected DN butterfly valve
D[mm] = 250,0	Inside-Ø of pipe
p_1[bar abs] = 5,00	Pressure upstream butterfly v.
t_1[°C] = 60	Temperature upstream butterfly v.
Fluid = Air	
ρ_1[kg/m³] = 5,23	Density upstream butterfly v.
ρ_N[kg/m^3_N] = 1,29	Density in normal condition
κ = 1,40	Isentropic exponent
Q_N[m^3_N/h] = 6.000	100% Volume flow rate "norman"
Q_1[m³/h] = 1.483	100% Volume flow rate "operating"
W[kg/h] = 7.757	100% Mass flow rate
Δp[bar] = 0,05000	Pressure loss butterfly valve

α °	Q_N m^3_N/h	Q_N Q_1 W %	K_V m³/h	V_1 m/s	V_2 m/s	ψ -	F_P -	L_A dB(A)
20	2.190	36	176	3,1	3,1	0,992	1,000	59
25	2.675	45	216	3,7	3,8	0,992	1,000	60
30	3.601	60	290	5,0	5,1	0,992	1,000	62
35	5.014	84	404	7,0	7,1	0,992	1,000	64
40	6.961	116	562	9,7	9,8	0,991	1,000	65
45	9.487	158	766	13,3	13,4	0,991	1,000	66
50	12.637	211	1.021	17,7	17,9	0,990	1,000	67
55	16.456	274	1.331	23,0	23,2	0,989	1,000	69
60	20.986	350	1.699	29,3	29,6	0,988	1,000	71
65	26.269	438	2.129	36,7	37,1	0,987	1,000	74
70	32.348	539	2.626	45,2	45,7	0,986	1,000	77
75	39.260	654	3.192	54,9	55,5	0,984	1,000	80
80	47.103	785	3.832	65,9	66,5	0,983	1,000	81
85	55.921	932	4.549	78,2	79,0	0,983	1,000	81
90	65.738	1.096	5.348	91,9	92,8	0,983	1,000	81
38	6.115	102	493	8,6	8,6	0,992	1,000	64



If V2> 110 m/s sound pressure level is invalid.

Sound pressure level calculated according to IEC 60534-8-3 (2000)

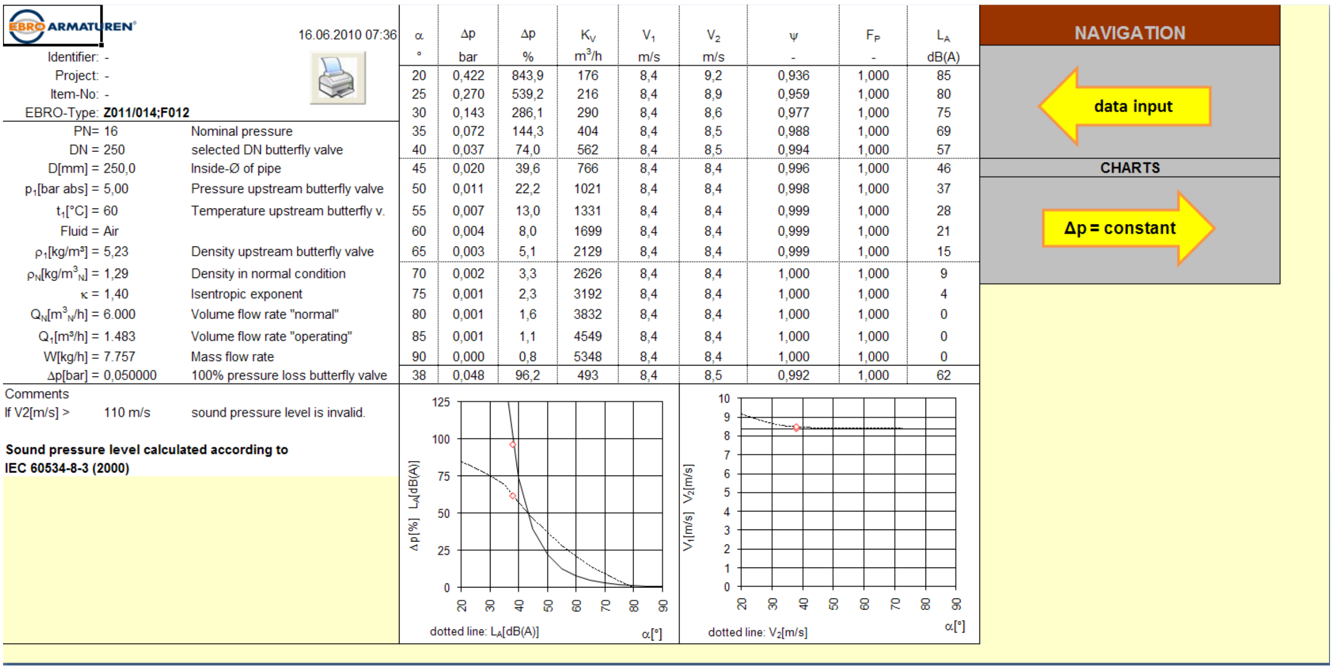
NAVIGATION

data input

CHARTS

Q = constant

Sheet with “Q = constant“:



α	Δp	Δp	K_V	V_1	V_2	ψ	F_P	L_A
°	bar	%	m³/h	m/s	m/s	-	-	dB(A)
20	0,422	843,9	176	8,4	9,2	0,936	1,000	85
25	0,270	539,2	216	8,4	8,9	0,959	1,000	80
30	0,143	286,1	290	8,4	8,6	0,977	1,000	75
35	0,072	144,3	404	8,4	8,5	0,988	1,000	69
40	0,037	74,0	562	8,4	8,5	0,994	1,000	57
45	0,020	39,6	766	8,4	8,4	0,996	1,000	46
50	0,011	22,2	1021	8,4	8,4	0,998	1,000	37
55	0,007	13,0	1331	8,4	8,4	0,999	1,000	28
60	0,004	8,0	1699	8,4	8,4	0,999	1,000	21
65	0,003	5,1	2129	8,4	8,4	0,999	1,000	15
70	0,002	3,3	2626	8,4	8,4	1,000	1,000	9
75	0,001	2,3	3192	8,4	8,4	1,000	1,000	4
80	0,001	1,6	3832	8,4	8,4	1,000	1,000	0
85	0,001	1,1	4549	8,4	8,4	1,000	1,000	0
90	0,000	0,8	5348	8,4	8,4	1,000	1,000	0
38	0,048	96,2	493	8,4	8,5	0,992	1,000	62

4.7 Abstract Flow Calculation Input and Output data

Input	Output
K_V-value	
DN, D, EBRO-Type	K_V, F_P, F_P*K_V
FLÜ	
p_1, t, Fluid Nr., Q, Δp, D, DN, EBRO-Type	ρ, η, p_v, p_c, DN_{Lmin}, DN-suggested, opening angle α
new Fluid: Name, ρ, η, p_v, p_c, (c_L)	Diagrams and Tables for Q = constant Diagrams and Tables for Δp = constant
GAS	
p_1, t_1, Fluid-Nr., Q_N, Δp, D, DN, EBRO-Type	Q_1, W, DN_{Lmin}, DN-suggested, opening angle α
new Fluid: Name, ρ_N, κ, (M)	Diagrams and Tables for Q = constant Diagrams and Tables for Δp = constant

5 Messages

Messages are displayed when entered data or results are out of range.

The input data of the flow calculation should not be out of range! When the input data are out of range the calculation can be incorrect!

Samples for Messages		
Input	**Message**	**Help**
t [°C] = 181	t > 180 °C	Choose a temperature below or equal to180°C
DN = 250; D = 300	DN < D ; D > DN	Choose a smaller DN or a greater D

6 Details

6.1 Velocity

For velocity in pipes the following details will be applicable:

Fluid flow: V to ca. 4,5 m/s

Gas/vapor flow: V to ca. 70 m/s

Exceptions were e.g.:

- Short pipes with V > 5 m/s at fluid flow (close slowly, pressure surge!)
- Relief pipes with V > 200 m/s at gas and vapor flow

6.2 Cavitation

Cavitation should always be avoided. Cavitation starts when the cavitation factor is $x_F/z_y > 1$.

A cavitation factor up to $x_F/z_y = 2$ should be allowed only temporary.

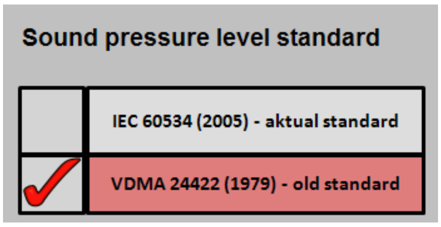
Exception: A cavitation factor up to $x_F/z_y = 3$ during opening or closing of the butterfly valve.

7 Calculation of sound pressure level L_A

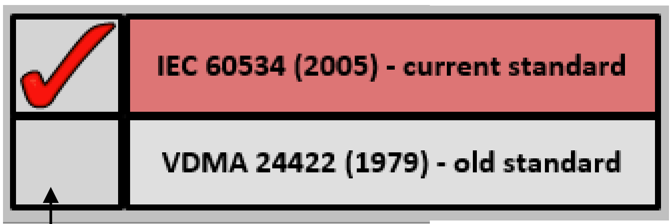
The calculation of the sound pressure level is possible in two ways:

1. Calculation according to VDMA 24422 (1989)

   This is an elder, but not an invalid standard. You can calculate the sound pressure level with this standard when you have no sound speed level of a fluid (FLÜ-Calculation Chapter 4.5) or no molar mass of a gas (GAS-Calculation 4.6).



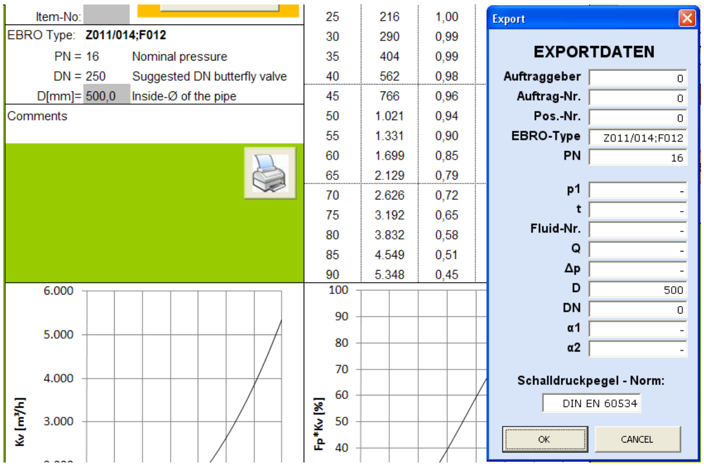
2. Calculation according to IEC 60534-8-4 (2005) for liquids or IEC 60534-8-3 (2000) for gases and vapors



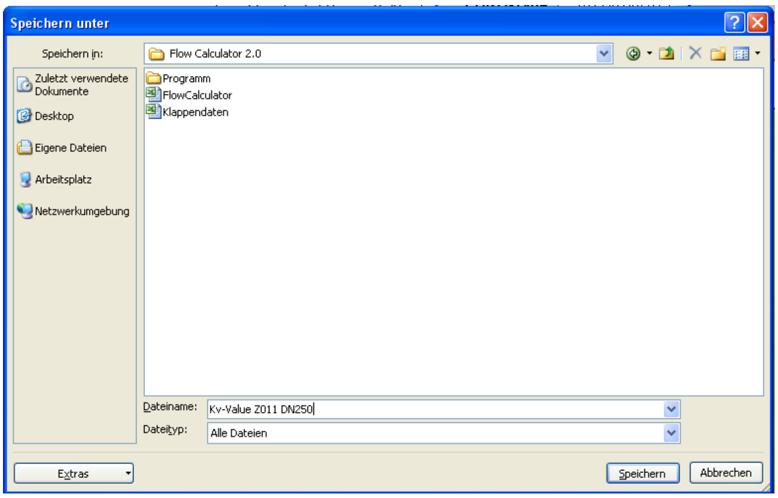
The standard for calculation can be changed by a click on the squares.

8 Export and Import of calculation

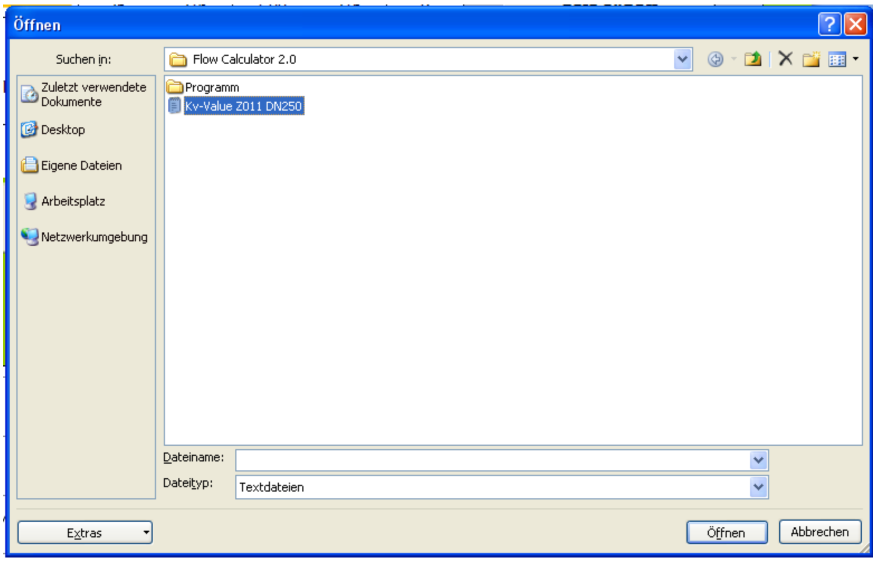
To save the calculation data you can export the data. When you need it again, you can import the data and can go on with the flow calculation. The export-box (only available in German language – but can also be used for the English version of the flow calculator) shows the entered data.



When you click on “OK” the next window for memory location opens. Now you have to select any file folder where you want to save the file. For example you might choose the “Flow Calculator 2.0” folder. Enter a filename <u>without a type of file</u>. It will be saved as a “txt”-file automatically (It isn’t critically if you enter a type of file – the file will also be a “txt”-file). By a click on the “save” button the data were saved.

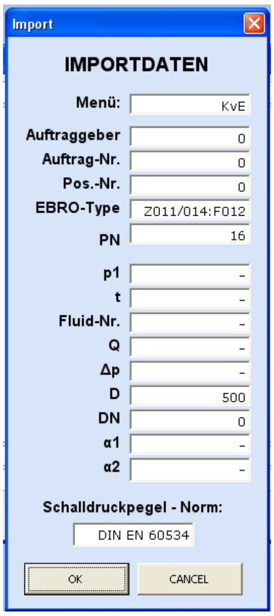


By a click of import you can import the saved data. Search the exported file, and open it.



The import-box opens and show the data which were saved. By a click on “OK” you can import them finally.

By a click on “cancel” you can abort the import.



9 References

[1] DIN EN 60534-2-1: Control valves for Process Control: Part 2: Flow Capacity. Main Section 1: Design Equations for Incompressible Fluids under Installation Conditions. January 1995.

[2] DIN EN 60534-2-2: Control valves for Process Control. Part 2: Flow Capacity. Main Section 2: Design Equations for Compressible Fluids under Installation Conditions. January 1995.

[3] VDMA 24422: Armaturen - Richtlinien für die Geräuschberechnung - Regel- und Absperrarmaturen. Mai 1979.

[4] DIN EN 60534-8-4: Control valves for Process Control. Part 8-4: Noise considerations - Prediction of noise generated by hydrodynamic flow (2005).

[5] DIN EN 60534-8-3: Control valves for Process Control. Part 8-3: Noise considerations; Control valve aerodynamic noise prediction method (2000)

[6] Ehrhardt, G.: Geschwindigkeit V_K im Drosselquerschnitt und kritisches Differenzdruckverhältnis x_T von Drosselklappen in Abhängigkeit vom Stellwinkel. Interne Studie (1987).

[7] Ehrhardt, G.: Durchflussmessungen an konzentrischen EBRO-Absperrklappen. Bericht Aerodynamisches Institut der RWTH Aachen vom 04.02.1982.

[8] Ehrhardt, G.: Durchflussmessungen an EBRO-Doppelexzenterklappen DN50 und DN65 im Februar 2001.

[9] WL Delft Hydraulics: Berichte vom Juli 1984 und vom Februar 1999 zu Versuchen an konzentrischen EBRO-Absperrklappen.

[10] WL Delft Hydraulics: Berichte vom Mai 2000 und vom August 2000 zu Versuchen an EBRO-Doppelexzenterklappen.

[11] EBRO ARMATUREN: Betriebsdaten. Lieferprogramm 1998.

[12] U. Grigull (Herausgeber): Zustandsgrößen von Wasser und Wasserdampf in SI-Einheiten. Springer-Verlag 1989.

[13] Deutsche Shell AG: Broschüren über Stoffwerte von Dieselöl und Thermalöl.

[14] VDI 2040: Berechnungsgrundlagen für die Durchflussmessung mit Drosselgeräten. Bl. 4: Stoffwerte. VDE/VDI -Fachgruppe Messtechnik 1970.

[15] Richter, H.: Rohrhydraulik. Springer-Verlag 1962.

[16] Ehrhardt, G.: Durchflussmessungen an EBRO-Exzenterklappen PN16: DN80, DN125, DN150 und DN50/65 im Juli 2004 und im März 2005.

[17] WL Delft Hydraulics: Bericht vom September 2003 zu Messungen an EBRO-Exzenterklappen PN16: DN50/65 und DN100 (Wafer-Type HP-IC).