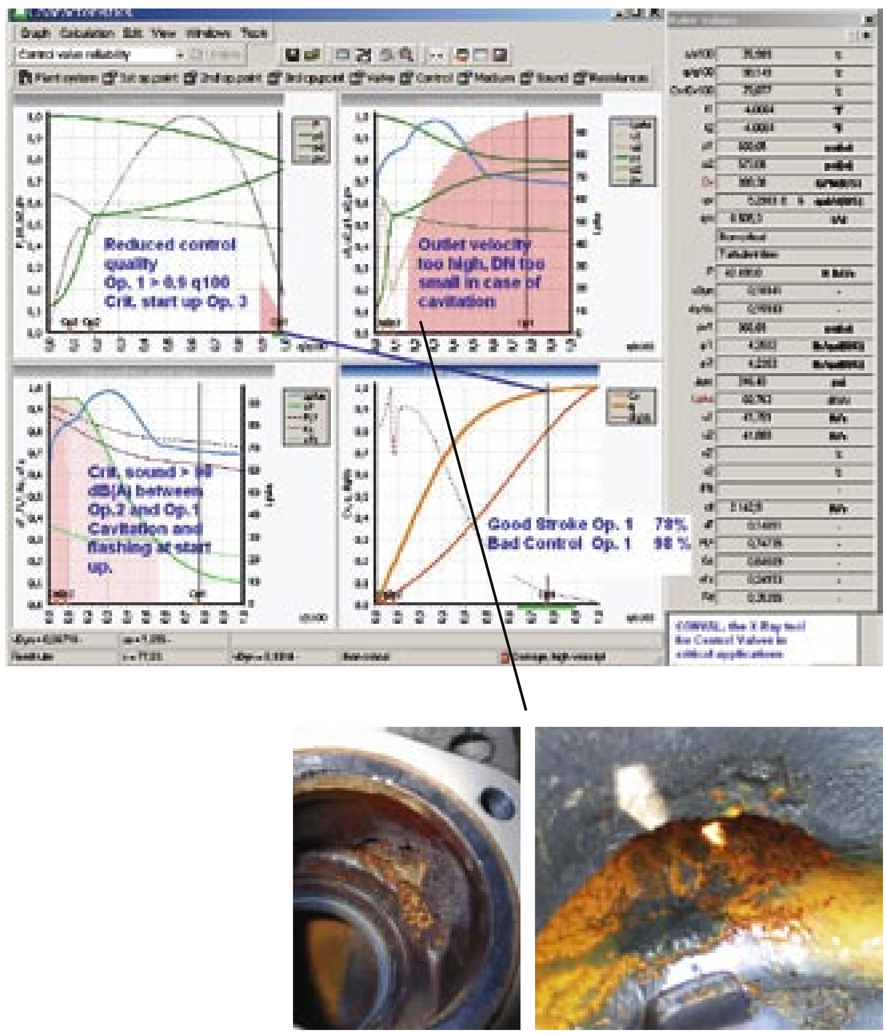
SAMSON

Plant design and control valve selection under increasing cost and time pressure

Part I and Part II



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By:
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Plant design and control valve selection under increasing cost and time pressure - Part I

By Dipl. Ing. Holger Siemers, SAMSON AG

Following a career spanning three decades, Mr Siemers is well aware of the pitfalls to be avoided when specifying control valves for a range of demanding applications. In his latest paper for Valve World, he looks further into plant design and control valve selection when working under increased time and cost pressure. This article is split into two parts: broadly speaking, part one looks at control valve operating points and provides a case history involving a mismatch. The author then introduces better valve sizing practices and uses this theory to resolve the problems introduced in the case history.
Part two starts by explaining the trends and definitions of inherent valve characteristics before focusing on "quick and dirty" sizing. The paper then addresses cavitation before concluding with the expert software available to help select the optimum valve characteristic form.

This publication will continue taking more the aspect of CONTROL QUALITY into account, which can also suffer under the increasing cost and time pressure. The success of the plant - production quality and production quantity - can directly depend on reasonable valve control quality, especially if valves are in "key" functions.

1. Plant design under cost and time pressure

Optimizing the pump start pressure with pressure loss calculation of the pipework is the key to save power and energy in the long-term as well as to reduce wear, noise, and maintenance cost.[1] Accurate calculation sheets for the pipework and the control valve can be printed out within 15 minutes for a plant system shown in Figure 1b using the manufacturer-independent CONVAL software for valves, pipes, and pipe devices, generating dynamic graphics of plant and control valve characteristics. See Figure 1a.

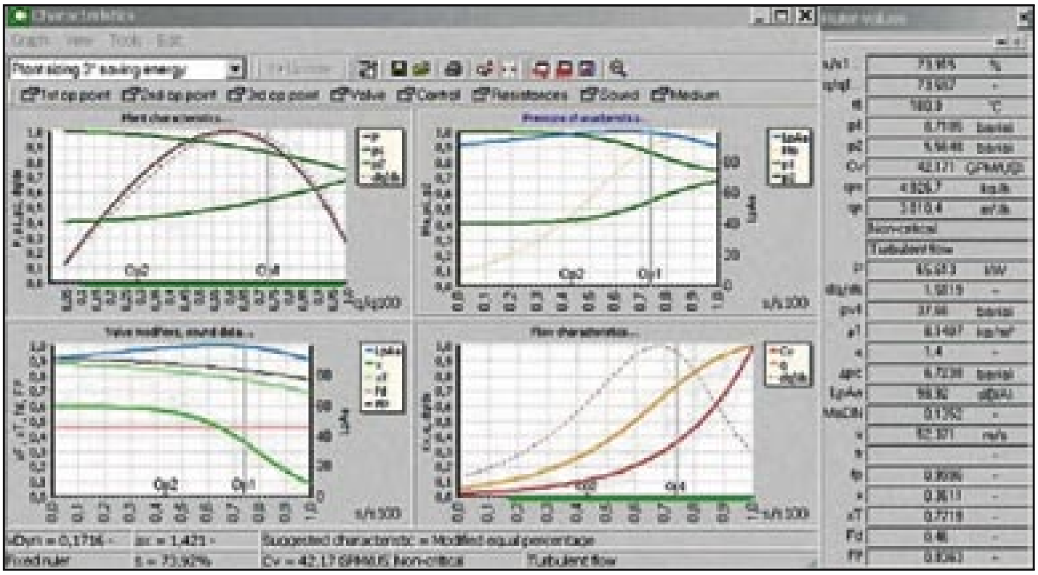


Fig. 1a: Result of proper control valve optimization using program parts: pressure loss; differential pressure flow elements and control valves

Tool for sizing, calculation, and optimization of common plant components:

- Control valves
- Steam conditioning valves
- Actuator forces
- Differential pressure flow elements
- Restriction orifice plates
- Safety relief valves
- Tank depressurization
- Pressure loss
- Pressure surge
  - **Pipes:**
  - Sizing
  - Pipe compensation
  - Span calculation
  - Pipe wall thickness
- Shell and tube heat exchangers
- Condensers
- Pump motor output

Supported by vendor-independent device databases (control valves, safety relief valves), fluid property calculation, material databases, ...

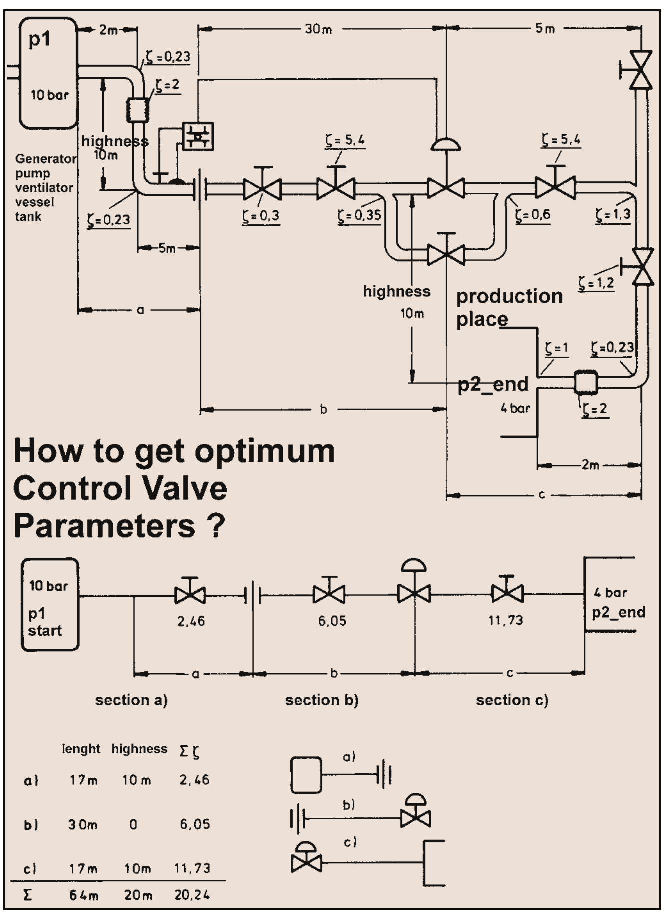


Fig. 1b: Plant system and proper control valve optimization with the CONVAL software

Obtaining optimum control valve parameters

The following seven steps will prove beneficial to obtaining the optimum control valve parameters:

1) Divide the plant pipework into three sections
   a) From pressure source - pump/vessel; start pressure to the flow meter upstream pressure.
   b) From the flow meter downstream pressure to the control valve upstream pressure.
   c) From the control valve downstream pressure to the plant end pressure (place of production)
2) Pressure loss calculation for qmax. qnorm. and qmin. section a)
3) Flow meter optimization with residual pressure losses at qmax. qnorm. and qmin.
4) Pressure loss calculation for qmax. qnorm. and qmin. section b) to start with flow meter downstream pressure. The yields the first result: the valve upstream pressure characteristic at qmax. qnorm. and qmin.
5) Pressure loss calculation for qmax. qnorm. and qmin. section c) to start with any control valve downstream pressure e.g. $p2 = p1 - \Delta pn$ ($\Delta pn = 1$ bar). Compare the result with the plant end pressure and iteratively correct the valve downstream pressure with the pressure drop deviation until the end pressure is reached. This yields the final result: the valve downstream pressure characteristic at qmax. qnorm. and qmin.

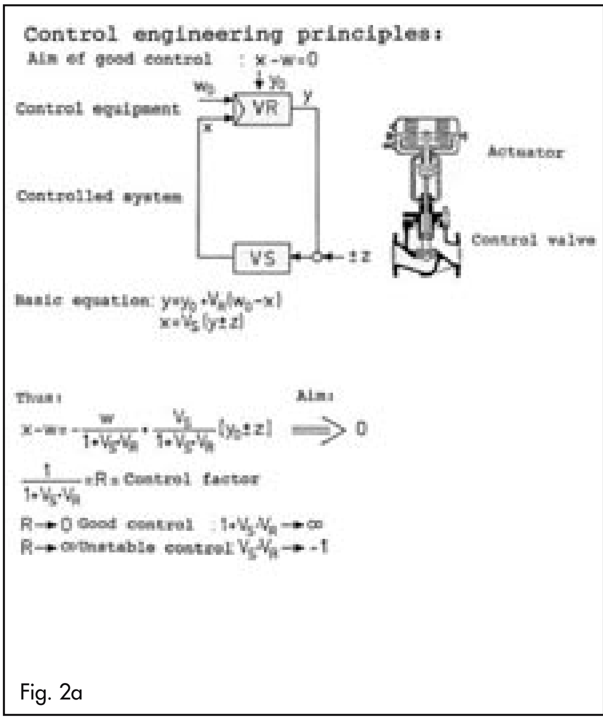


Fig. 2a

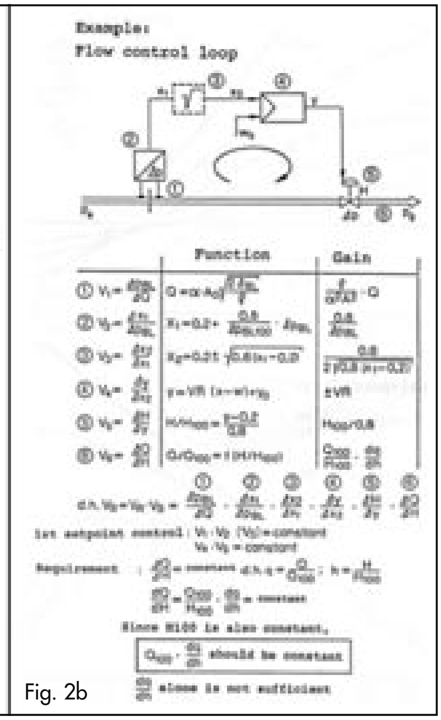


Fig. 2b

Fig. 2a: Control valve: the converting link between control equipment and controlled system

Fig. 2b: Importance of valve gain fluctuations to control quality

6) Control valve sizing and optimization leads to the selection of the most suitable control valve. Valve parameters to optimize: Cv100 value and the valve inherent characteristic
7) Check the control parameters: control range, $q_{max} < 0.9xq100$, valve gain $0.5 < gain < 2$ and SPL dB(A) characteristic: The loop gain depends on the control variable Flow q, Level L, Temperature T or Pressure p: $\Delta q / \Delta s$; $\Delta L/\Delta s$; $\Delta T/\Delta s$ or $\Delta p/\Delta s$. $p=p1$; p2 or Δp. Check the valve max. power consumption and select a valve which withstands its highest stress situation at max. power. For a new plant, more than fifty per cent power savings can be achieved by sizing the plant and valve parameters more accurately. [1, 4]

2. Control valves today are converting links between budgets!

Increasing cost and time pressure have considerably affected plant designers. To explain the change of planning parameters from the past to today, a simple pneumatic control loop (Figure 2a) could help to understand the upcoming problem. The control valve is the connecting link between the CONTROL EQUIPMENT and the CONTROLLED SYSTEM. Control equipment can include signal transmitters, actuators, single controllers or complex DCS systems. The controlled system includes pumps, pipework, and pipe devices like valves. If all signal transfer devices 2) to 5) operate in a strictly linear way the flow meter and the control valve as signal transfer devices 1) to 6) also need to work as linearly as possible to achieve an excellent control quality (Figure 2b).

If different departments are responsible for the control equipment and for the controlled system with their specific budgets the need of the valve pressure differential is quite often forgotten. If the differential pressure ratio is too small, the control valve will lose control authority.

The responsibility for control quality depends on the valve authority, the valve inherent characteristic quality and the characteristic form but also on the selected cv100 value. Mismatching can lead to an uncontrolled process variable and excessive gain fluctuations up to loop hunting. Under the worst-case conditions the investment targets of production may not be met.

Case study: Good stroking, bad control

In many cases the traditional engineering practice does not fit the needs of today. Additional engineering rules should be added to, or even used to replace, the traditional engineering practice which only takes the relationship "valve stroke versus flow" into account.

Quick selecting only looks at the traditional "stroke versus flow" requirements for the given operating point qmax. But the stroke $s < 0.8$ is not of interest here. Stroking to $s=1$ will increase the flow only by about 1.7 %. Here it is not the valve manufacturer's responsibility but rather the plant designer's problem to get the production under control and to increase valve authority at qmax., for example with more pump power.

Planning mistakes often occur as a result of too small budgets and missing control competence. Figure 3 (bottom right) shows that the operating point qmax is situated at "good" < 0.8 s/s100 stroke but not controllable at 98.3 % flow. See also warning alarm in the top left chart. The plant target to get a reasonable control of qmax. (means production quality as well as production quantity) cannot be achieved.

Sources of planning mistakes

Planning mistakes can result from a number of situations, including: excessive pressure loss due to pipe and pipe devices, insufficient pump power; not enough expenditure on plant design; failure to take the need for necessary differential pressure ratio for control valves into account; no accurate pressure loss calculation with too many assumed parameters. To de-bottleneck, if neither changing the pipe DN nor saving pressure loss is possible then one troubleshooting option includes increasing the pump power with new pump or pump impeller (see Figure 5).

3. From traditional to modern Development and Engineering Practice (DEP) for plant designers

The history of traditional "valve stroke versus flow" requirements dates back to earlier times (Figure 4a) when heavy-duty top-guided and bottom-guided or cage-guided valves were oversized and over-engineered in stroke and body weight for the standard applications of today. At that time, only linear or equal percentage valve characteristics were known. In the time of plant pioneers, new processes were installed for the first time on a lower scale production volume. Valve trims were reduced several times to double the production regarding increasing market demands. In the same way pumps and pipe devices were installed with flow reserve.

Today plant parameters are well known. From an economic point of view globe valves are often selected with the largest seat. If designed with too small a residual pressure differential globe valves need to be replaced with high flow capacity rotary valves. CONVAL's graphical support can show and self-explain advantages and disadvantages and the risk of over-sizing.

In general engineering practice, the control valves at system end (short circuit performance) should not be oversized.

The standardized plant system with total valve authority $\Delta p100 / \Delta p0 = 0.1$ shows the impact of an ideal equal percentage and linear inherent valve characteristic. Figure 4b compares good control parameters with an equal percentage and bad control parameters with a linear characteristic.

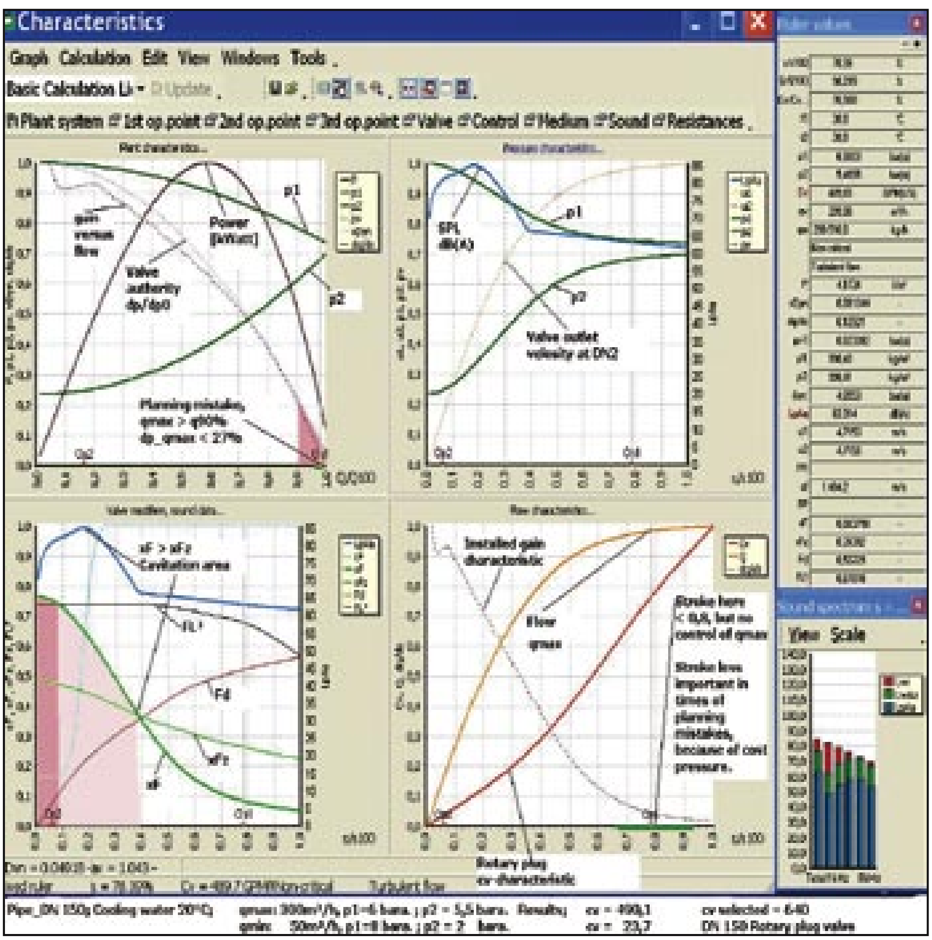


Fig. 3: Typical results of time and cost pressure: no control of production target qmax

To calculate the control rangeability from 5 to 100 % stroke and gain fluctuation: The gain fluctuations Δq / Δs versus flow as a function of the total valve authority [$v = \Delta p100 / \Delta p0$] (see Figures 4c and 4d).

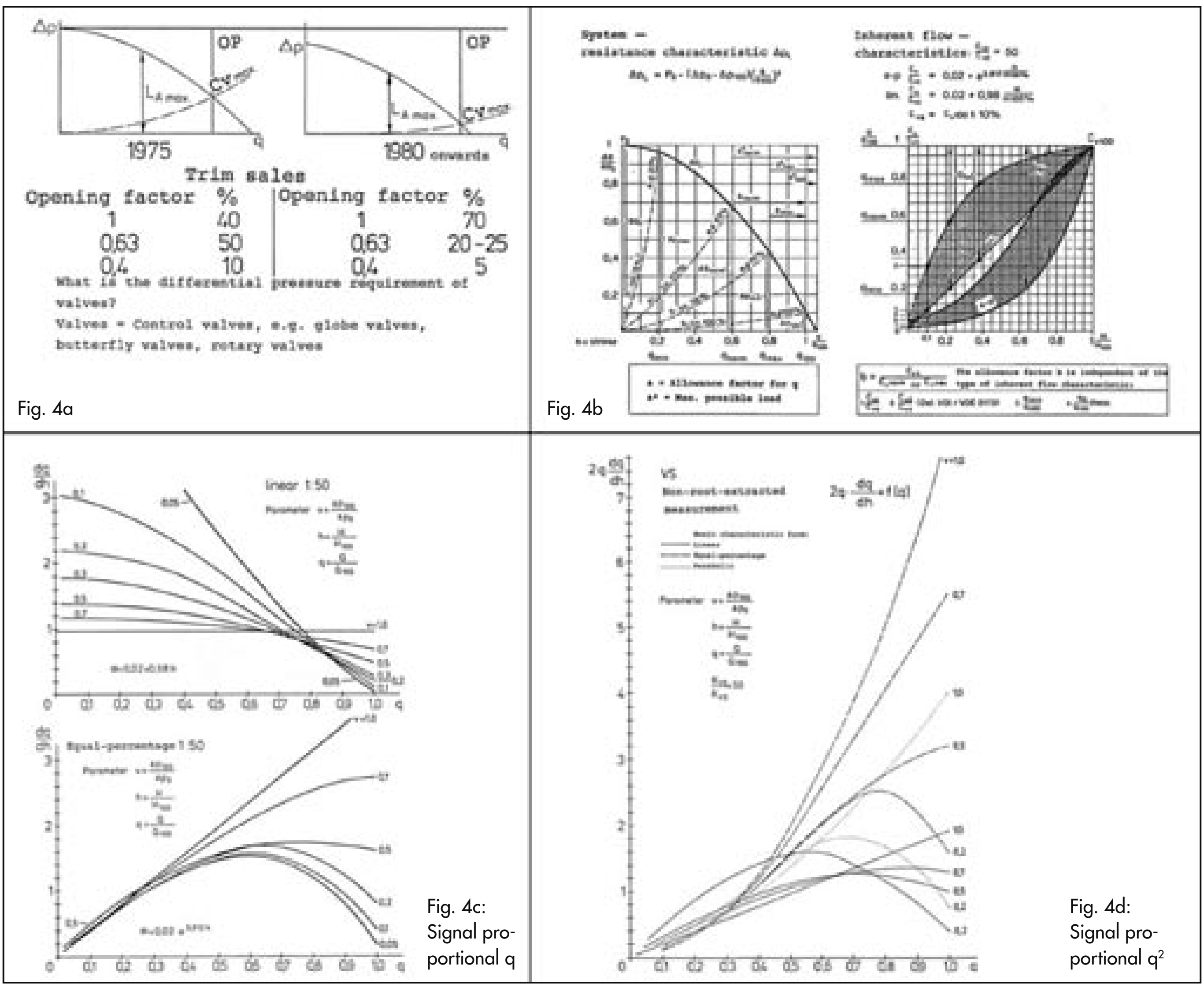
Following the SHELL development and engineering practice (DEP) 32.36.01.17 GEN control valve selection, sizing and specification in principle recommends plant designers follow the plant design rules indicated below for pump, pipework, and pipe device design. Important is for the "split responsibilities" to work together. One recommendation is to replace the "operating point versus stroke" requirements under the responsibility of plant designers and valve manufacturers to avoid considerable loss of control quality.

Plant designers' responsibility (Figure 5a)

The process design flow qmax. shall stay ≤ 0.9 x q100. q100 as a function of the selected cv100 value can be replaced with a valve manufacturer independent relationship: - the max system flow : 0.9 x q100 can also defined to 0,85 q* as the distance to the max. system flow. (q* = q_90 x qs = short circuit performance without control valve).

At qmax. = 0.9 x q100 =0,85 x qs the valve authority shall design $\Delta p90 / \Delta p0 \geq 0.27$. qs=q*/q_90 can be calculated for gas and liquid as a function of p1 and Δp and minimum selection between qs_1; qs_2; qs_3:

Characteristic eq. : 1 : 15;	$0.5 < \Delta q / \Delta s < 2$ ok
Characteristic lin. : 1 : 5;	$0.5 < \Delta q / \Delta s < 2$ not ok



Figs. 4a to 4d: Plant system trends and how to keep gain fluctuations (control quality) under control

The short circuit performance of system upstream pressure characteristic [2] is given by:

Liquid: $$qs\_1 = \frac{q^*}{q_{90}} = \frac{1}{\sqrt{1 - \frac{p_{1\_90} - p_v}{p_{1\_0} - p_v}}}$$

Gas; Steam; $$qs\_2 = \frac{q^*}{q_{90}} = \frac{1}{\sqrt{1 - \frac{p_{1\_90}}{p_{1\_0}}}}$$

The short circuit performance of system pressure differential characteristic [2] is given by:

Liquid; gas; steam: $$qs\_3 = \frac{q^*}{q_{90}} = \frac{1}{\sqrt{1 - \frac{\Delta p_{90}}{\Delta p_0}}}$$

(e.g. if $\Delta p90 / \Delta p0 = 0.27$ $qs\_3 = \frac{q^*}{q_{90}} = 1{,}17$ this results to the valve independent rule for plant designers q_90 = 1/1,17x q* = 0,85 x q*)

Valve manufacturers' responsibility (Figure 5b)
The valve cv100 value shall keep the total valve authority $\Delta p100 / \Delta p0 \geq 0.1$. If $\Delta p100 / \Delta p0 = 0.1$ the valve characteristic shall be chosen as equal percentage as possible. Figure 4b shows the relationship for any other "flow versus pressure drop" relationship for the plant parameter total valve authority $\Delta p100 / \Delta p0 = 0.1$ only if an ideal equal characteristic is selected.
Consequently following the new suggested regulations the mismatched plant system as shown in Figure 3 can be optimized in the early stage of planning.

Flow q/q100	Valve authority V = Δp / Δp0	Stroke,Travel s/s100 eq. char.
1	0.1	1
0.9	0.27	0.85
0.8	0.42	0.77

4. The new DEP for troubleshooting the mismatched case study from section 2
Figures 6a and 6b show a new upstream pressure characteristic increase p1 at qmax from 6 to 7.5 bar abs and at qmin. from 8 to 9.5 bar abs with installing higher pump power. A DN 150 globe valve with AC low noise trim could be the choice for SPL < 80 dB(A). (See Figure 6a.)

Figs. 5a, b, c: How to avoid loss of control quality using proper plant parameters and valve sizing

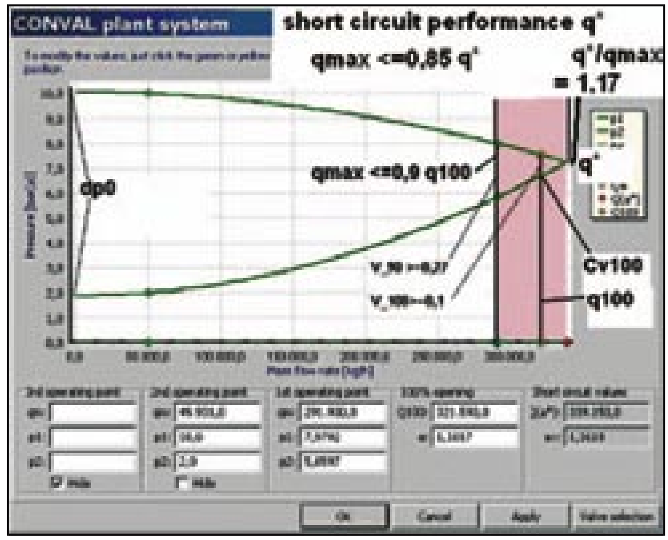


Fig 5a: Plant designers' responsibility

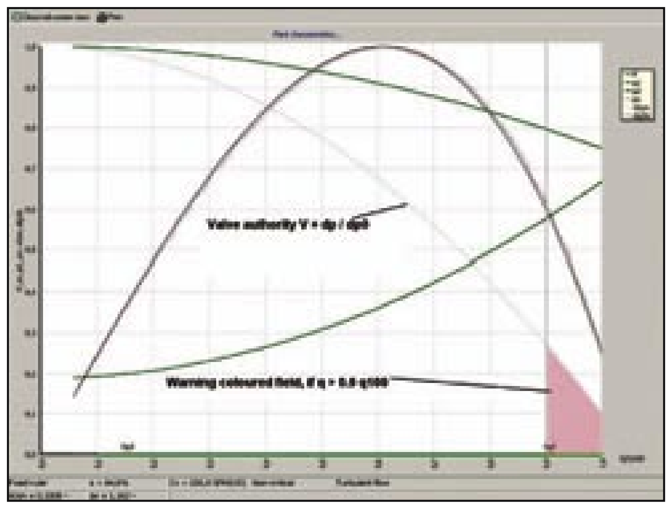


Fig. 5b: Valve manufacturers' responsibility

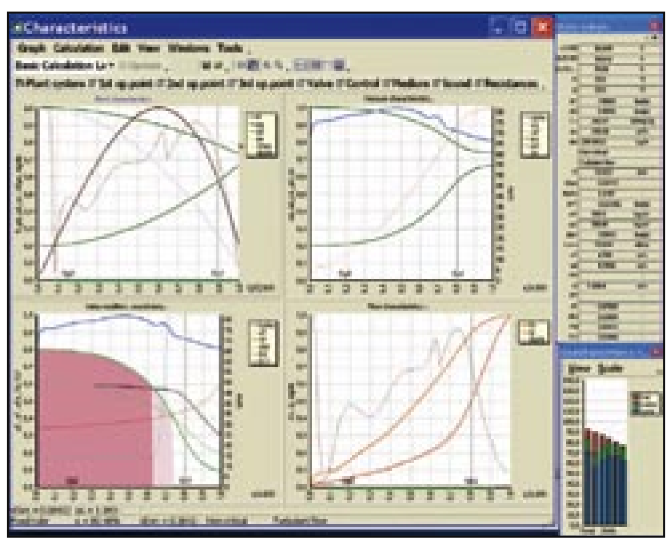


Fig. 5c: Valve authority Vdyn = 0.27 at q_max = 0.9 q100 for a low noise cage ball valve ™ (PiBiViesse, Italy), 6 inch

The installed flow characteristic gain variation stays within the engineering practice rule: $0.5 < \Delta q / \Delta s < 2$ in the entire range of control. From qmin up to q100 presented this reasonable gain borders with the bottom green line in the top left and bottom right graphs in Figures 6a and 6b. If replacing the globe valve with a rotary plug valve of the same cv100 value the installed flow characteristic drifts in on-off direction (Figure 6b). The installed flow characteristic's higher gain fluctuations still stay within the engineering practice rules: $0.5 < \Delta q / \Delta s < 2$ between the operating points qmax and qmin: shown with the bottom green line in the top left and bottom right graphs. The sound pressure level can exceed > 85 dB(A). The software further indicates choked flow up to 30% travel and min. flow control at small opening 5%. This can easily be further optimized with a smaller cv100 value by reduced seat technology and adding integrated low-noise devices. In case of higher DN, high shut down pressure, exotic materials, and within the given sound requirements a rotary plug valve could be a reasonably priced alternative to globe valves.

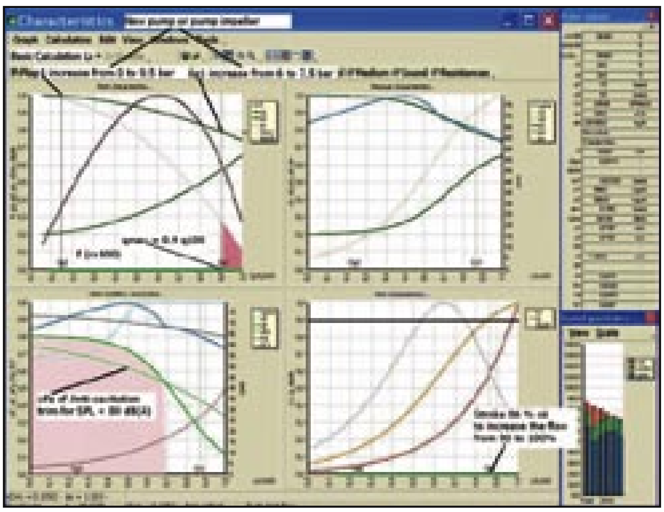


Fig. 6a: Correction of planning mistakes from Figure 3 with more pump power selecting a globe valve

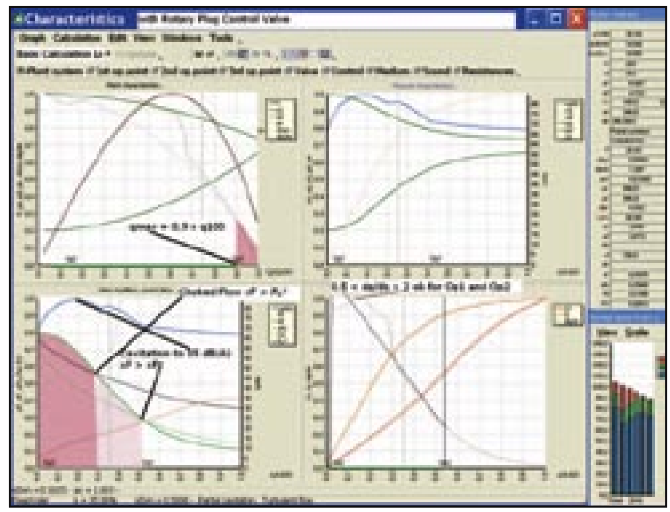


Fig. 6b: Correction of planning mistakes from Figure 3 with more pump power selecting a rotary plug valve

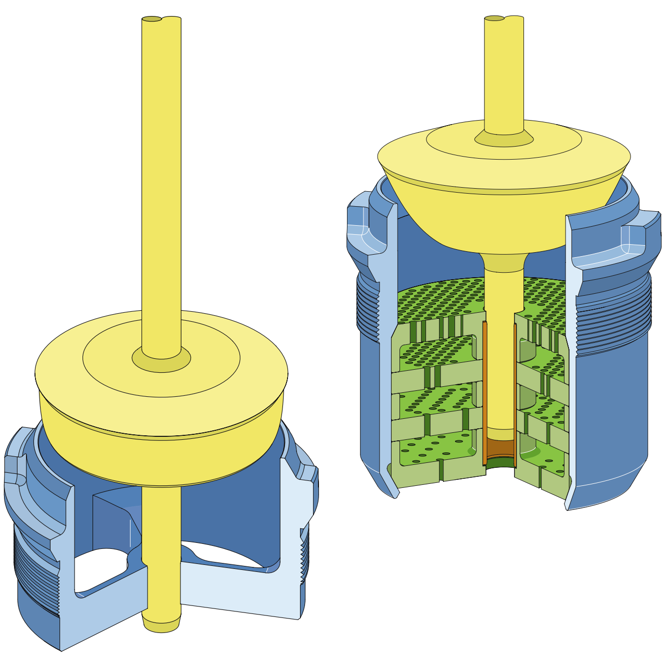


Fig. 6c: The SAMSON AG AC-Trim system can solve upcoming cavitation problems after de-bottlenecking [3]

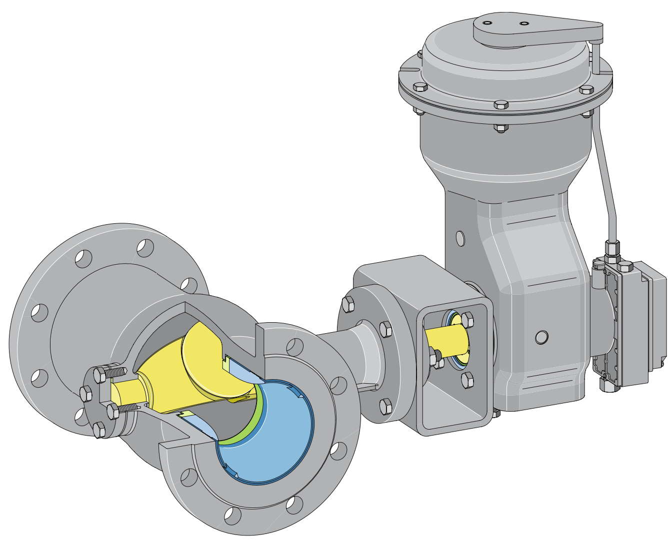


Fig. 6d: The VETEC rotary plug valve in specific areas is a reasonably priced alternative to the globe valve

Plant design and control valve selection under increasing cost and time pressure - Part II

By Dipl. Ing. Holger Siemers, SAMSON AG

This is the second and final section of Mr Siemers´ technical paper addressing plant design and control valve selection when working under increased time and cost pressure. The first section focused on control valve operating points and provided a case history involving a mismatch before introducing better valve sizing practices. Part two starts by explaining the trends and definitions of inherent valve characteristics before focusing on "quick and dirty" sizing. The paper then addresses cavitation before concluding with the expert software available to help select the optimum valve characteristic form.

Part I

1. Plant design under cost and time pressure
2. Control valves today are converting links between budgets!
3. From traditional to modern Development and Engineering Practice (DEP) for plant designers
4. The new DEP for troubleshooting the mismatched case study in section 2

Part II

5. Trends and definitions of inherent valve characteristics for globe and rotary valves
6. Detail engineering sources for plant and valve designers have dried out!
7. Noise reduction and getting the plant power under control
8. Selecting the optimum valve characteristic form
9. Using software to increase control quality, reduce cost and save time for creativity

5 Trends and definitions of inherent valve characteristics for globe and rotary valves

Gain requirements of valve inherent characteristics are defined in IEC 543 2-4 with a tolerance band of ±10 % within the limits: $0.5 < \Delta cv / \Delta s < 2$. This was a compromise to the former stricter national regulations of VDI 2173 with $0.7 < \Delta cv / \Delta s < 1.3$ and ±10% of the cv100 value. See Figures 7a to 7c.

Because today there are many types of inherent valve characteristics, from the globe control valves to quarter-turn control valves, IEC 534 2-4 has defined basic requirements for the characteristic quality (see Figures 7a to 7e).

In general, all kinds of characteristics are supported, but they are to be published if they are not of the ideal linear or equal percentage type, i.e. outside the tolerance band defined in IEC 534 2-4. The ideal equal percentage characteristic of globe valves from former times cannot be achieved with modern economic standard globe valves, which also have to follow general market demands to the highest flow capacity (cv x 100)/DN 2 at lowest initial cost. Today, the inherent characteristics of globe valves are somewhat modified equal percentage in the competitive range of published highest cv values. To be competitive, valves need to be offered mostly with the largest seat diameter (smallest nominal size DN), if not specified otherwise.

Cam and positioner signal technology used to linearize any mismatching is not the "door to heaven"; rather, advantages and disadvantages need to be discussed separately. [4]

Figures 7d and 7e show that there is an interaction between the valve characteristic form, the flow capacity and the power consumption. This is shown here with liquid measurements of xFz characteristics versus load cv/cv100. Valves with higher xFz values convert the power [dp x q x const.] [1] better to heat by flow friction than high flow capacity valves, which convert more to flow velocity and therefore cavitation occurs at smaller pressure drops.

Modern control valves are designed for specific marked segments like chemicals, food & beverage and pharmaceuticals.

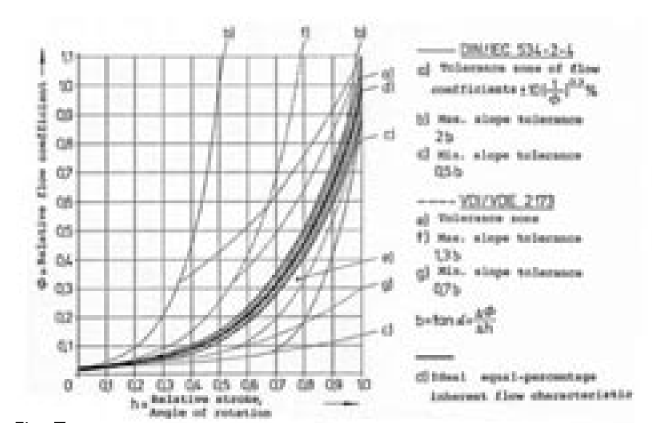


Fig. 7a

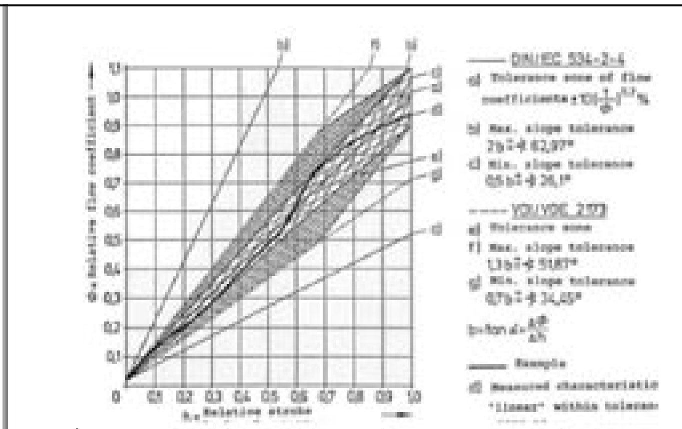


Fig. 7b

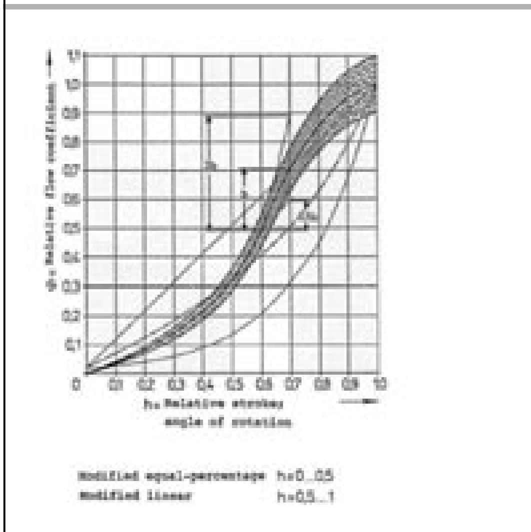


Fig. 7c

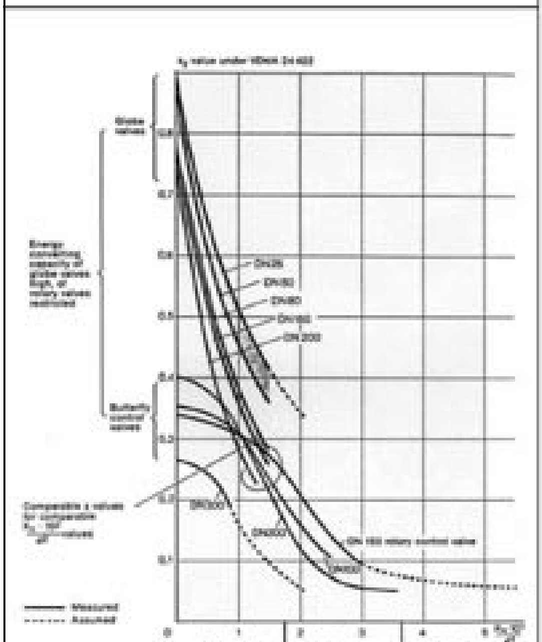


Fig. 7d

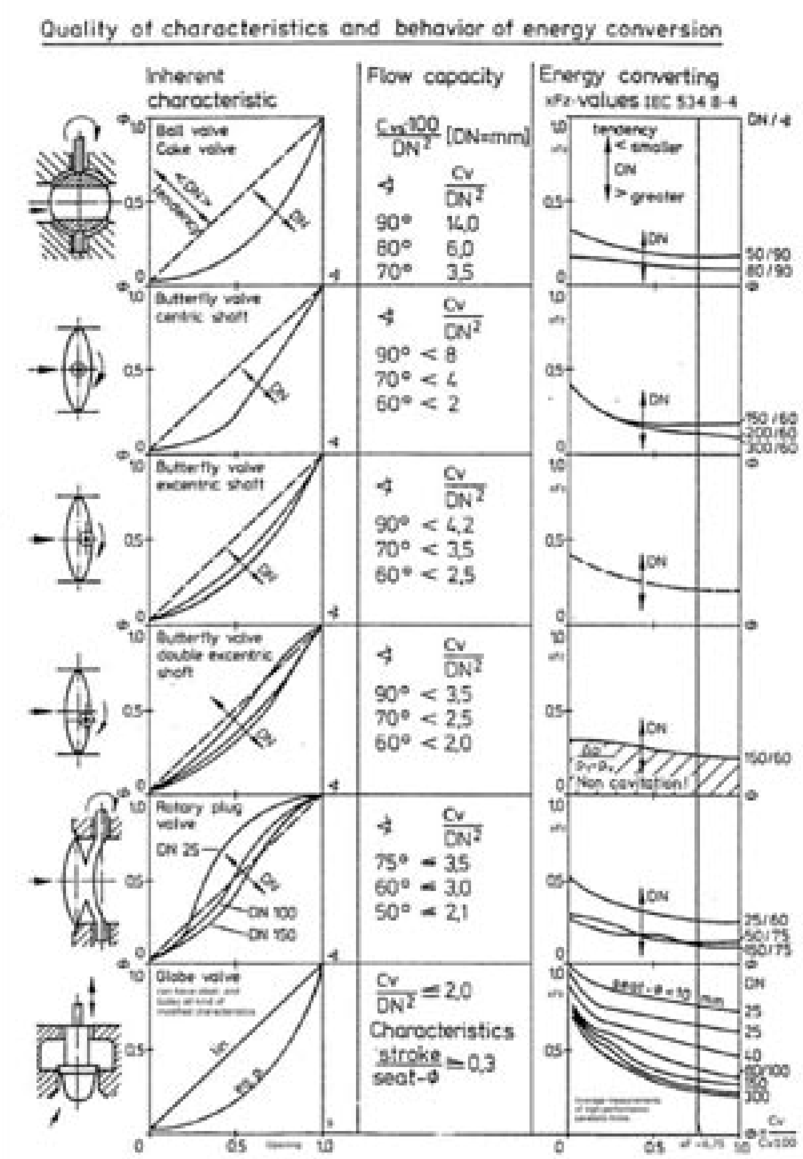


Fig. 7e

Figs 7a to 7e: Inherent valve characteristic versus flow capacity versus power converting capability -xFz f(cv/cv100)-

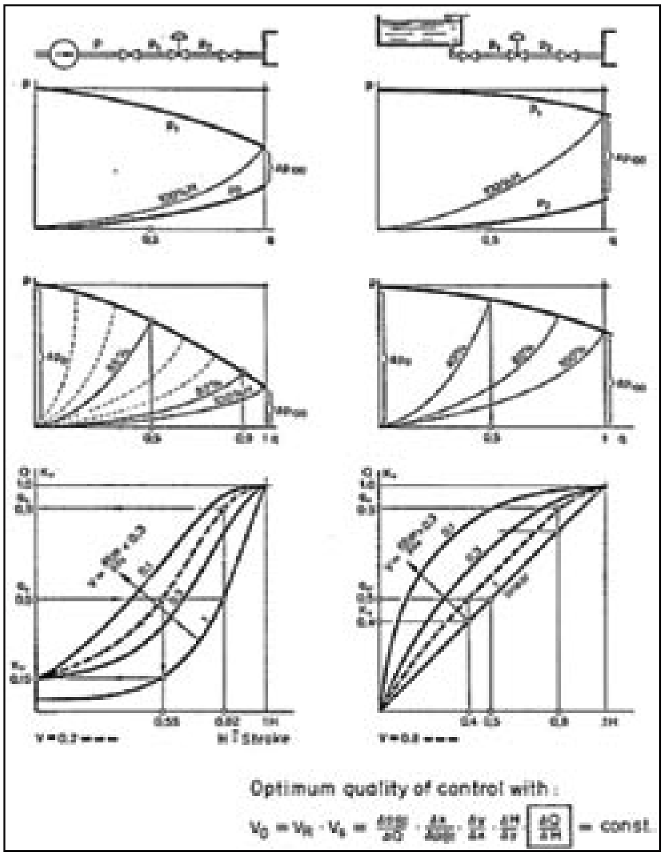


Fig. 8a: The interaction of valve authority parameters to different installed flow characteristic

On a higher price level they are used for the downstream hydrocarbon processing industries and oil and gas market. And at the top price level they are mainly applied in the onshore and offshore upstream market, in oil and gas exploration, separation, storing and transport, or they are tailored for special demands. In the HPI market, control valves are more often "power converting machines" up to 300 MW used as flare valves, blow down or anti-surge control valves and for other special demands. Those valves in the severe service area in all nominal sizes and pressure ratings are on average approximately four times more expensive—including more detail engineering—than valves of non critical standard applications in chemical plants in the range of DN <= 6 inch and PN <= Class 300.

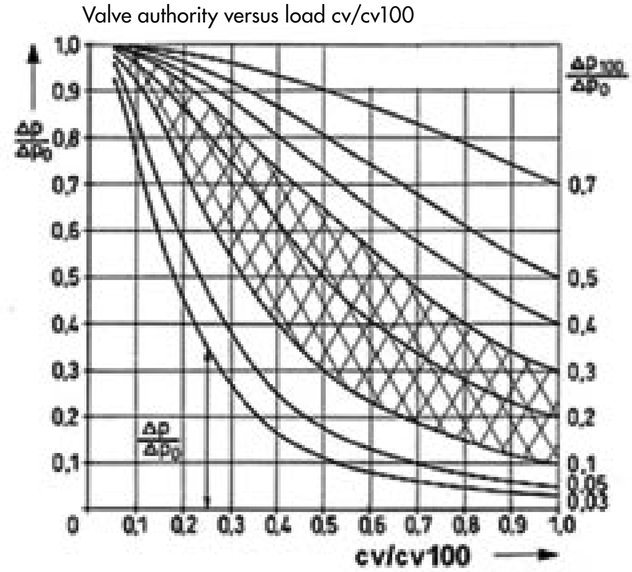
6 Detail engineering sources for plant and valve designers have dried out!

Plant and valve designers in the field of severe applications need time to optimize control quality, the sound level and power consumption as well as to handle increasing regulation paperwork and economic aspects. Sizing control valves from a total point of view is a challenge for the project engineer as well as for the valve manufacturer specialists, even if they use modern powerful in-house sizing programs and tools. Those "valve guys" need long-term experience and high skills in measurement and control, mechanical engineering and thermodynamics. In comparison to the past, the time available for major projects has been more than halved, the specification volume—including the increasing paperwork associated with standards, special regulations and tailored customer requirements have more than doubled.

Negative effects of today are: valve specification sheets are often of low quality, operating points are missing or not logically sorted to qmax, qnorm, qmin, Important property data (like the vapour pressure) may be missing, no information about the worst-case conditions like during start-up, no control loop information etc. No wonder that sources of competence for high-level engineering for valves with higher demands have dried out and the risk of "quick and dirty" sizing is increasing.

Given today's quality standards ISO 9001: 2000 and the upcoming SIL (IEC 61508) requirements even for non emergency shut down ESD serial valve products, do we really need SIL for special severe service valves? Also, as products are more often being offered under e-purchasing conditions characterized by an increasing cost and time pressure, the author would like to point out that care needs to be taken in this area, particularly for severe service valves. Proper control valve selection requires detail engineering with competence. We should not save initial costs by cutting back on detailled engineering and shifting higher cost to other after-sales budgets, e.g. troubleshooting, maintenance and, at worst, plant shutdown or accidents.

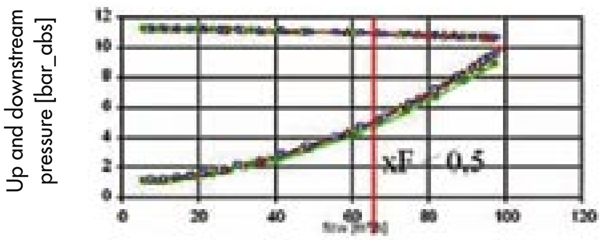
Valve authority versus load cv/cv100



The valve authority characteristic is independent from the valve characteristic. The hatched area includes > 80% of all applications.

Fig. 8b: Characteristic of the plant parameter xF as a function of the load cv/cv100 and the valve authority

Plant characteristic, pump power 50 [kWatt]



Globe valve comparison:
If xF > 0.5, risk of high SPL dB(A) and resonating stem for top guided parabolic trims DN > 1.5 inch. Difference > 30 dB(A) between valve Type d) and AC Anti-Cavitation Trim System-Top and seat guides special parabolic trim.

Type of valves: a to e, Cv100 from 91.7 to 131
Plant adjustment: dp_100/dp0 = 0.1 direct replacement with a to e.

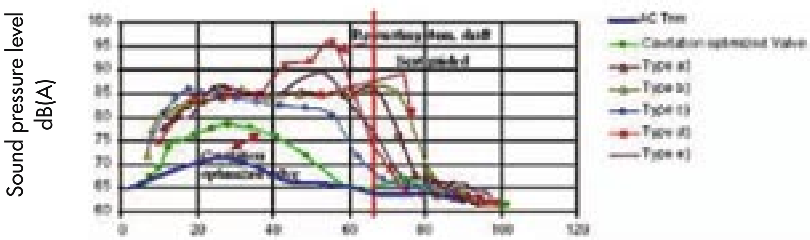


Fig. 8c: The interaction of globe valve design parameters to the liquid sound emission

The CONVAL software looks at plant parameters (pipework, pipe devices, flow meters and valves) from an overall point of view with expert system features to compensate for the negative trends described above. The integrated mighty valve database can store every brand valve function like inherent valve characteristic as well as all defined valve recovery factor functions.

7 Noise reduction and getting the plant power under control is not that easy under time pressure

Figures 8a to 8d show the interaction of different valve authority parameters with the liquid sound emission and the challenge to select the most economic valve for each unique plant design. Figure 8a shows examples of a pump-generated plant system with total valve authority V=0.3 and a tank level control process with total valve authority V = 0.7.

All possible valve authorities versus valve load cv/cv100 are shown in Figure 8b. The hatched area may include > 80% of all applications. Cost pressure drives the trend towards the bottom line V < 0.1, unfortunately with a negative impact on good control parameters. This sometimes calls for undersizing cv 100 < cv max to avoid excessive gain fluctuations.

Figure 8c shows different standard globe valve qualities with comparison measurements of seven globe valves. Adjusted to the same cv100 value the valves create SPL differences between 65 and 95 dB(A) depending on valve design parameters like

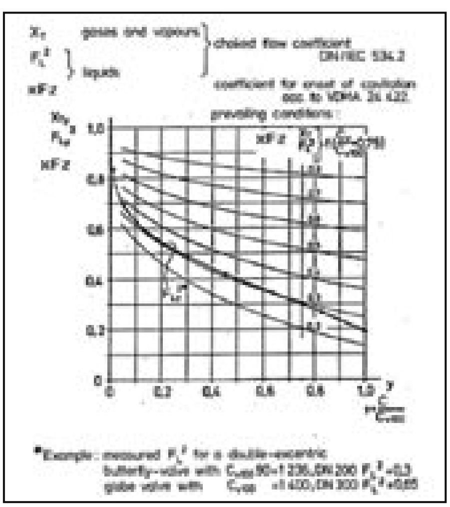
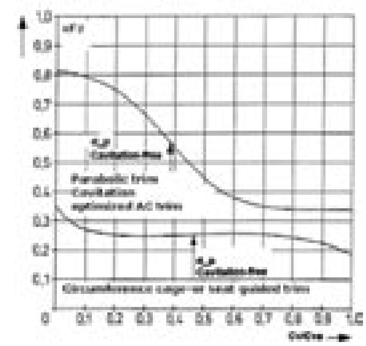


Fig. 8d: Approximation of valve recovery factors for standard valves (flow to open - FTO), if only one value at load cv/cv100 = 0,75 is given

Fig. 8e: Real-time test rig at SAMSON AG



Typical globe valves xFz-characteristic curves for sound SPL dB(A) prediction regarding IEC 534-8-4

Fig. 8f: Typically measurements of xFz-characteristic for parabolic plug trims (FTO) and circumference guided trims

Recommendations to improve the optimum inherent valve characteristic form. The valve manufacturer cannot influence the valve upstream and downstream pressure characteristic - plant design responsibility. The valve manufacturer can influence the valve authority V if the optimum cv100 valve is chosen. CONVAL recommend five typically characteristics forms of valve families found today.

Total valve authority dp100/dp0	Valve authority dp00/dp0 Qmax = 0.9 q100	Inherent flow characteristic for optimum, installed flow characteristic, which is as linear as possible
V ≤ 0.1	Vgmax < = 0.27	Equal percentage DIN IEC 534-2-4
0.1 < V ≤ 0.15	0.27 < Vgmax < = 0.31	Equal percentage up to s = 0.8
0.15 < V ≤ 0.3	0.31 < Vgmax < = 0.43	Modified equal percentage
0.3 < V ≤ 0.5	0.43 < Vgmax < = 0.6	Modified linear
0.5 < V ≤ 1	0.6 < Vgmax < = 1	Linear

Example for flow control with measurements dp proportional to flow. If other characteristics are chosen from other aspects of view, eg, dynamic aspects, the control loop may have more gain variations. (If not out of limits, who cares?)

Fig. 9: Borders of the inherent valve characteristics forms as a function of the valve authority

top-guided parabolic, top seat-guided contour plug or top seat-guided parabolic AC trim. If no measurements from the valve database are available, valve recovery factors versus valve load cv/cv100 are used in the software for flow and SPL calculation as a first approximation for parabolic plugs (flow to open).
Figure 8e shows a real-time test rig for comparison measurements as demonstrated in Figure 8f with xFz measurements -xFz versus valve load cv/cv100- for different plug guidance principles. In critical cases detailled engineering is necessary to find valves with xFz characteristics Figure 8f overlaying the curves in Figure 8b to avoid cavitation over the entire control range.
In applications with steam or gases, highly sophisticated noise reduction measures also need to be taken, giving priority to the valve outlet velocity, especially in case of flashing, which is not noise sensitive. [1, part 2]

8 Selecting the optimum valve characteristic form

This is the last point to improve control quality but also the most difficult. In case of pressure control from a static point of view, an equal percentage characteristic stands for a more constant gain $\Delta p/ds$; p=p1, p2, or Δp independent of the valve authority. But anti-surge pressure control mostly calls for a linear characteristic because of dynamic reasons to protect the flow machine as quickly as possible.
The software looks at all loop parameters using questions and answers as illustrated in the table in Figure 10. The recommendation then is the characteristic form with advantages in comparison to others.

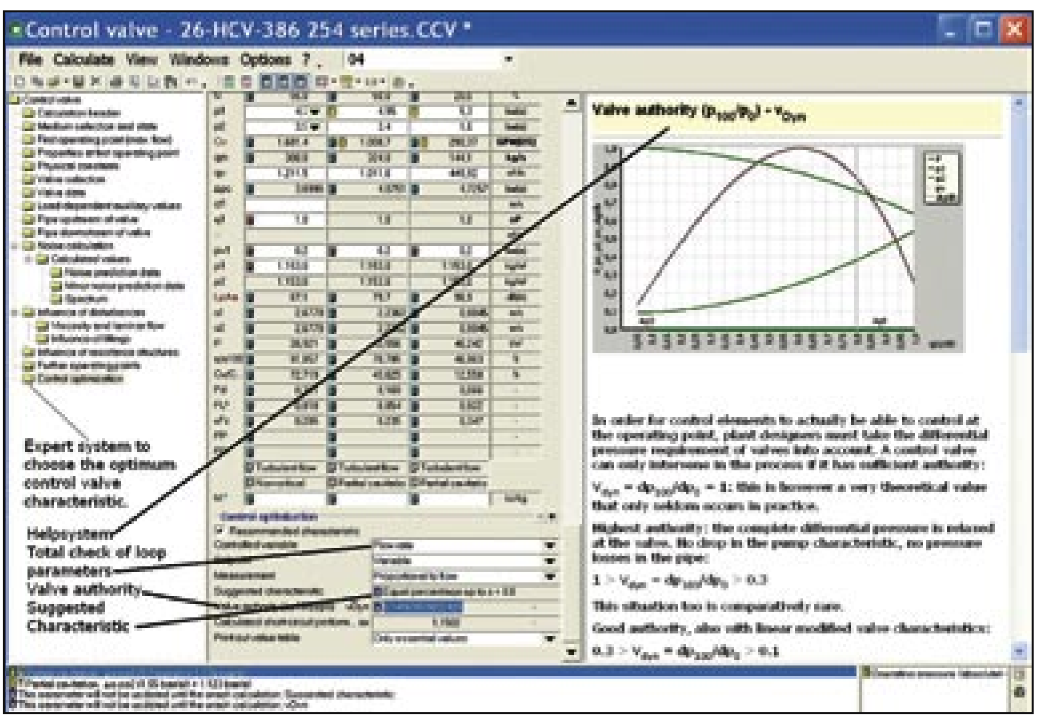


Fig. 10a: Questions and answers in CONVAL to select the best characteristic form for the control variable flow, level, temperature and pressure. See also Fig. 10b.

It does not mean that other characteristics are not practicable. It only means that they will produce higher gain fluctuations, which can be checked separately by the graphical support of the software. Figure 9 shows the borders of valve authorities where the program shifts to the next better valve characteristic form.

Nevertheless, attention should still be paid to some more specific loop parameters for the final software decision of the best characteristic form. (See Figure 10b.)

After calculating the specific valve authority the software expert system goes through the tables by questions and answers and recommends the optimum valve inherent characteristic form (Figure 10a).

9 Using software to increase control quality, reducing cost and saving time for creativity

The CONVAL® 6 software treats the plant and valve sizing parameters from an overall point of view, issuing dynamic graphics with installed characteristics concerning flow, power, gain, and outlet velocity as a function of the valve coefficient cv and the valve travel. The software is a manufacturer-independent optimization tool for pipelines and pipe devices. Including material and property database for more than 3,000 substances like hydrocarbons and chlorine. About 60 industrial fluids are calculated very accurately using equations of state developed by Ruhr University in Bochum, Germany.

(See www.conval.de for more details.) If operating conditions are given with one, two or three operating points the plant system is defined in the standardized differential pressure versus flow diagram.

The inherent cv characteristic of any valve as well as all other valve characteristics xFz, Fl, xT, Fd, etc. are stored in a mighty valve database in form of equations or polynomial coefficients. Every valve installed characteristic like flow, gain, and valve authority, sound, inlet and outlet velocity as well as cavitation, flashing and choked flow areas are presented in graphic form. A dynamic ruler indicates all results including alarms at any valve travel position.

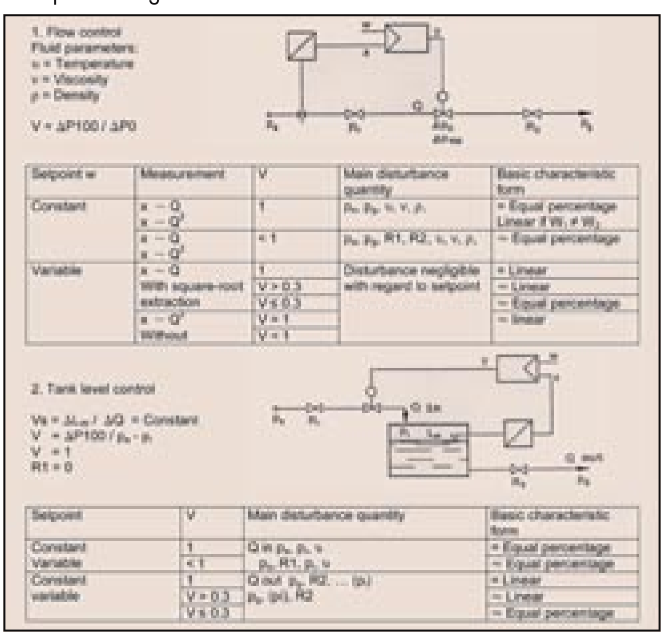
The program combines expert valve sizing with powerful plant optimization and troubleshooting.

The software successfully detected valve sizing mistakes in several of the 1,200 control valves installed in a German refinery before the regular plant shutdown after five years' operation. With the software "troubleshooting features" the refinery therefore ordered spare parts in time and started up without any delays.

The software provides a bi-directional COM link to spreadsheets and CAE systems as well as in-house valve sizing programs which companies can use to store valve data e.g. sound measurements, administration of inquiry and quotation systems as well as pricing and drawings. (See Figure 11.)

Recommendations for improving the basic characteristic form

It is assumed that only one of the disturbance quantities acts as the main disturbance quantity. The symbol "=" in front of the characteristic means that the control loop parameters remain constant; "≈" before the characteristic means that the parameters change in the event of a disturbance or setpoint change.



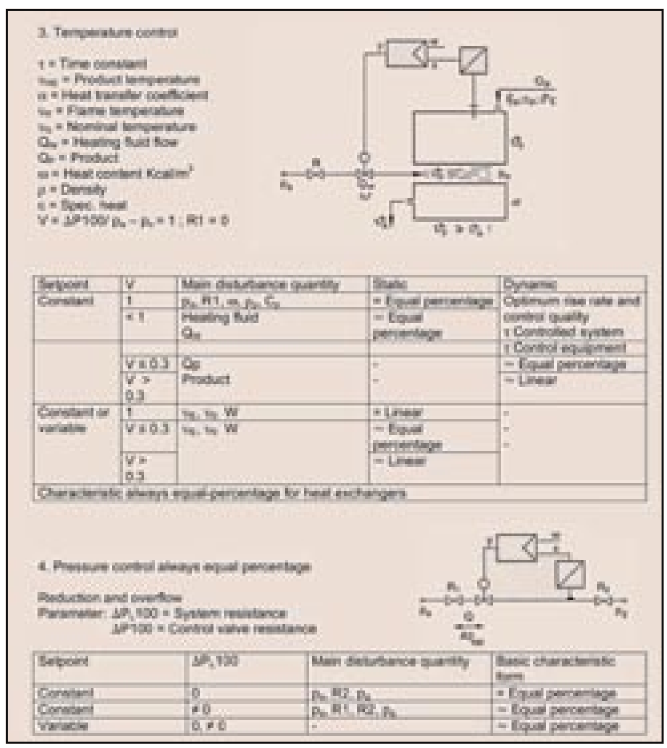


Fig. 10b: CONVAL question and answers table to select flow control, level control, temperature control and pressure control

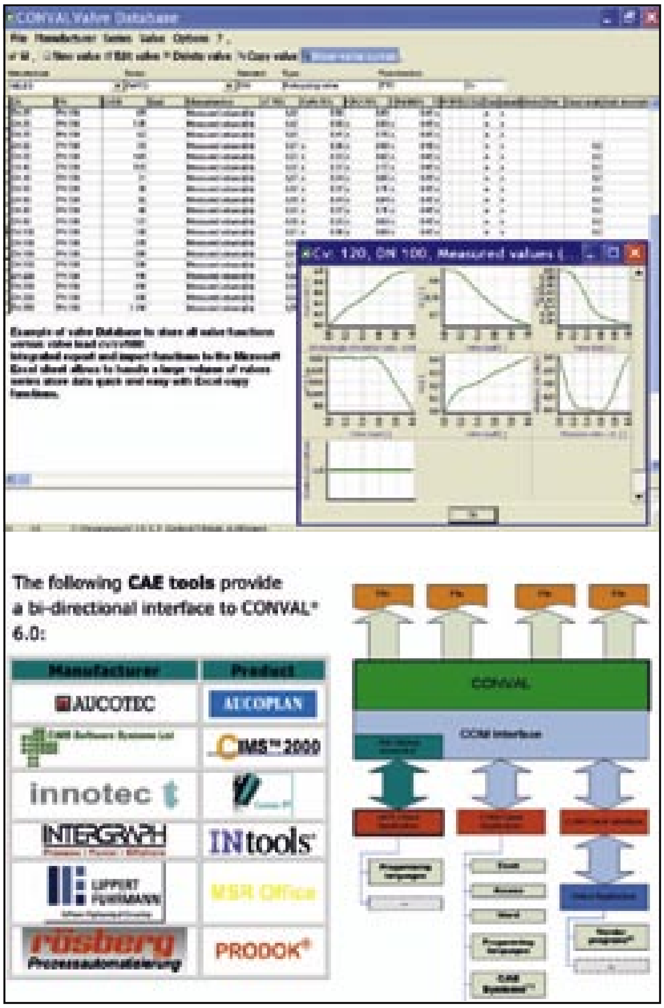


Fig. 11: Valve database for sizing, calculation and optimization of all kinds of valves and common plant components and the bi-directional interface structure

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[1] Siemers: Control Valve Design Aspects for critical applications in petrochemical plants. Part I.
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[3] Dr. Kiesbauer: Control Valves for Critical Applications, Hydrocarbon Processing, June 2001.

[4] H.D. Baumann : Valve Primer, A User`s Guide Chapter 7 ISA Edition.

About the author

Mr Holger Siemers, who gained a Dipl. Ing. Degree from the University of Furtwangen, started his career with ECKARDT AG company. He was former head of the Control Valve Sales Department in ECKARDT; ECKARDT FOXBORO; SIEBE INVENSYS. He was one of the founder members of VDMA 24422 79 and 89 which will become the worldwide standard IEC 534 8-4 - Sound Prediction Methods for liquids.

He was also chairman in the VDI Working Group: Valve Characteristics, gave support and copyright of CONVAL (the plant and valve optimization tool) and was involved in the R&D of silencer technology - Multi-hole orifices with deliveries of 2500 silencers in the past twenty years.

He has troubleshooting experience with sound, loop stability, life cycle and plant performance problems and been involved in valve optimization for demanding applications in petrochemicals and refineries (hydrocarbon- processing, HPI, LNG, PTA, ...).

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