Determining Flow Values for Lanny Valves

Making the most of flow data – fast access to the right values for your application

Content:

1 Introduction

Accurate flow values are essential for the design and optimization of fluid systems. In many practical cases, however, only a limited number of simulation data points are available. These are not sufficient to determine an arbitrary combination of inlet pressure, outlet pressure, and flow rate. This whitepaper explains how spline interpolation can be used to generate a high-resolution dataset from a small number of simulated points. This enables reliable evaluation of flow behavior – both along existing characteristic curves and between them.

2 Fundamentals of Flow Behavior

The flow through a technical system is governed by fundamental physical laws. It primarily depends on the pressure difference between inlet and outlet, as well as on the system's flow resistance. Factors such as the flow type (laminar or turbulent), the viscosity of the medium, and geometric features like cross-sectional changes also influence flow behavior.

Methods for Evaluating Flow Values in Practice

In practice, various methods and units are used to define and evaluate flow values. These include:

- **C_V (Flow Coefficient)** – common in the Anglo-American region; describes flow at a 1 psi pressure drop across the component.
- **C (Sonic Conductance)** – according to ISO 6358, used in pneumatics; describes flow in the critical range.
- **Effective orifice area** – an empirically determined value, often used for simplified characterization.
- **Nl/min** – normal liters per minute, based on standardized reference conditions.
- **Actual flow rate** – simulated or measured under real operating conditions.

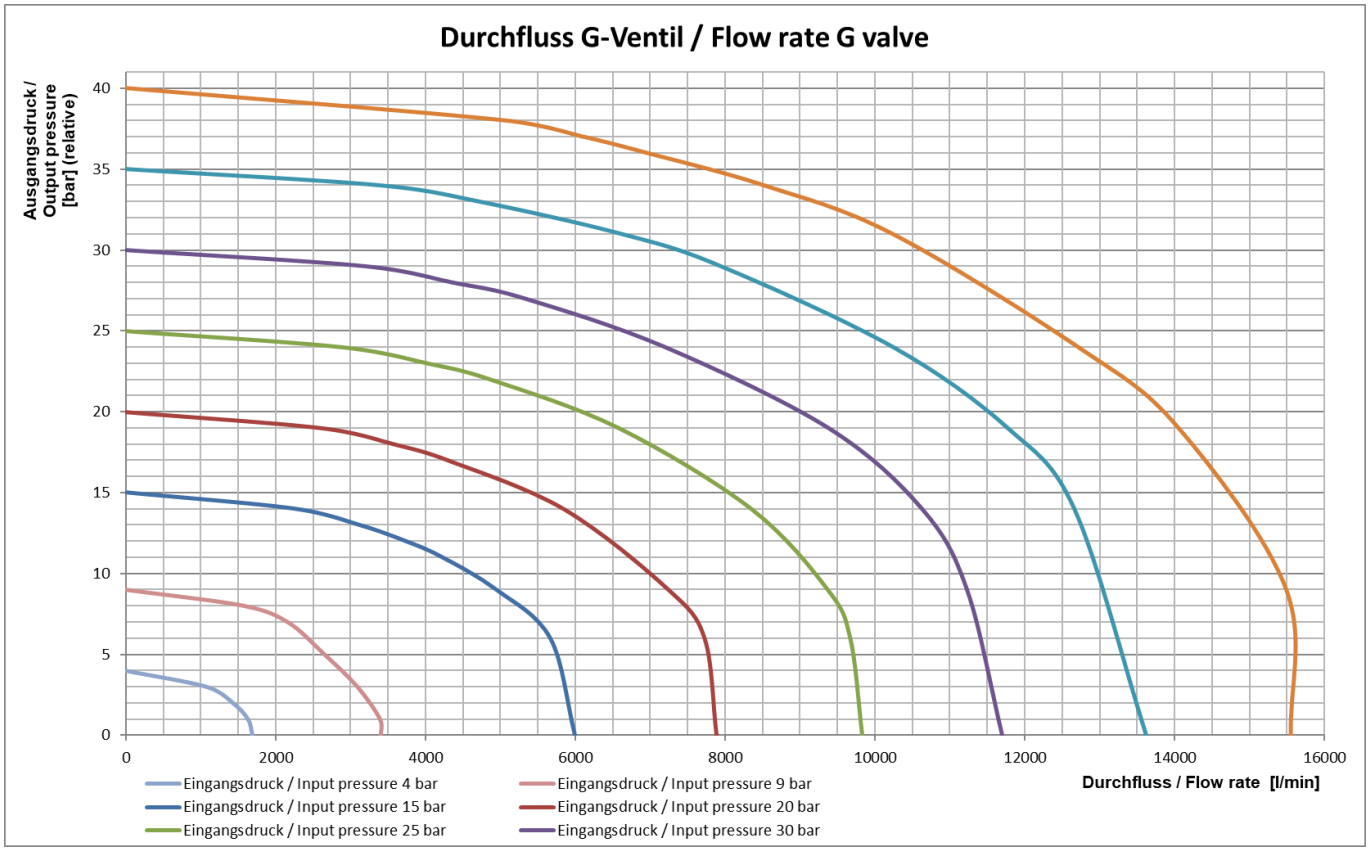

Figure 1: Characteristic curve field with flow values, using the example of G valves from MLS Lanny

This diversity often leads to misunderstandings in the field. Different manufacturers use different standards and reference conditions, or do not specify pressure drop, for example, making comparability difficult. For the user, this means that precise knowledge of the reference values and test conditions used is essential for correct component selection and reliable interpretation of design results.

At MLS Lanny, we have deliberately chosen to specify the actual flow rate under the relevant boundary conditions (see Figure 1, example for the G valve family). This is the most reliable representation of the real physical situation and can be used directly for the design. Based on this decision, we prepare the values in the form of flow characteristics that graphically represent the volume flow as a function of outlet pressure for different inlet pressure levels. In this way, we ensure that our customers can design and dimension directly with the values shown - without uncertainty due to different interpretations of evaluation key figures.

3 Current provision and use of flow data

The flow characteristics we currently offer are available in the form of characteristic plots. These show the flow rate in [l/min] as a function of the outlet pressure, each for a fixed inlet pressure. In practice, this means that each curve represents a specific inlet pressure level, such as 10, 20 or 30 bar. The data is typically based on simulations or real measurements and consists of a limited number of discrete points.

For our customers who want to design a system based on these curves, this presents a particular challenge: values can only be read directly for the simulated inlet pressure stages - and even that is not always easy, as the curves are only available in graphical form. It becomes even more difficult when an inlet pressure is required that lies between two existing stages. In such cases, only a rough estimate can be made, which can lead to design uncertainties (see Figure 2).

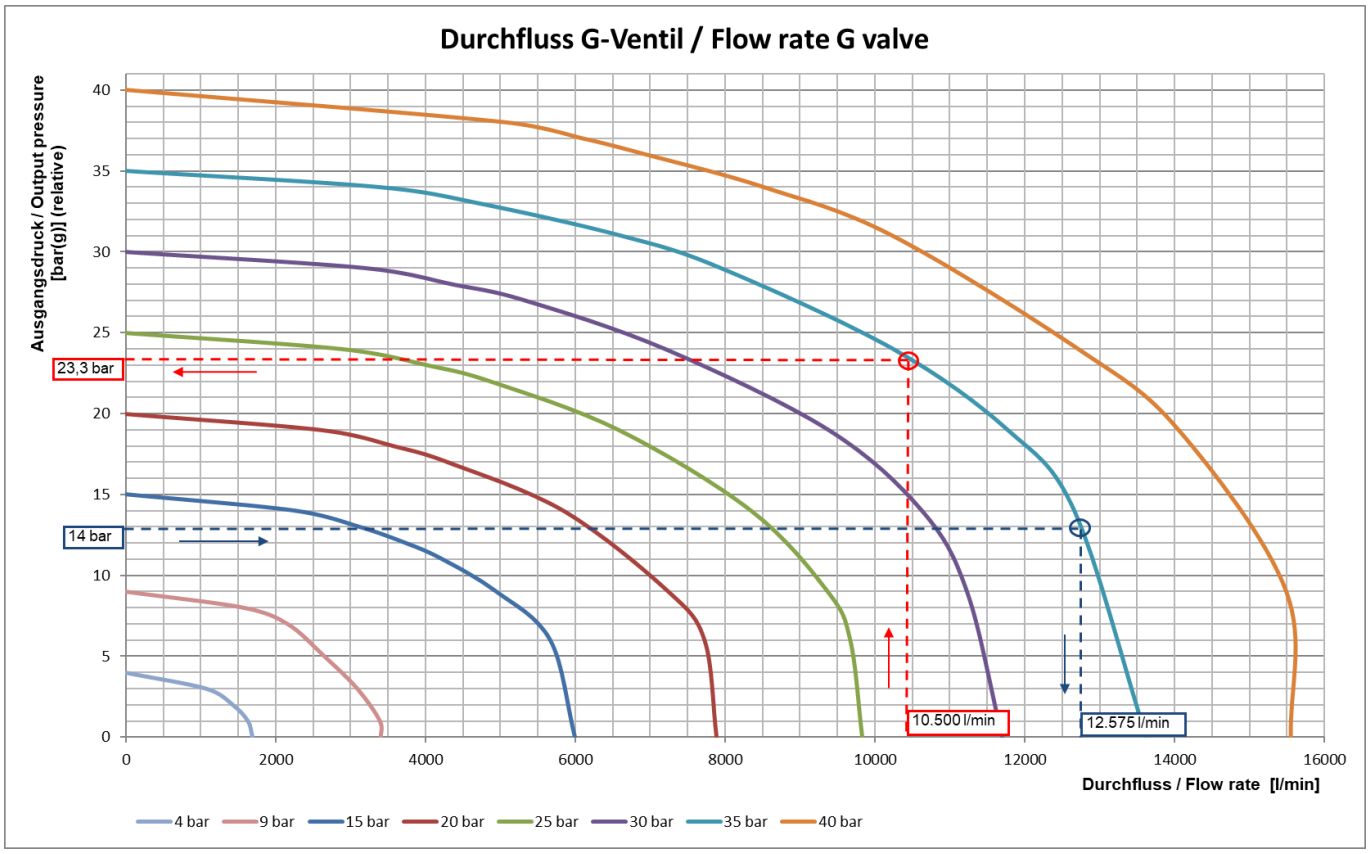

Figure 2: Reading of specific values from a flow curve (example: G-valve)

4 Objectives and Methodological Challenges

The goal of our further development is to generate a much denser database from the few discrete data points obtained from the simulation. This forms the basis for precise interpolation - both along the curves (i.e., at constant inlet pressure) and between the curves (for intermediate values at varying inlet pressure).

This is a prerequisite for the development of a digital tool that allows the user to enter two out of three parameters - inlet pressure, outlet pressure, flow rate - and have the third value calculated automatically. This allows for flexible, fast, and reliable use of performance data in practical design.

The use of linear interpolation or a fixed-order polynomial fit often provides inadequate results for real, non-linear curve shapes. Typical problems include:

- Overfitting with high polynomials
- Fuzzy or discontinuous transitions between curves
- Lack of accuracy for intermediate values

An additional problem arises when interpolation across different inlet pressure levels is required, e.g., to determine a flow value at 27 bar inlet pressure when data is only available at 25 and 30 bar.

5 Data compression through spline interpolation and application in practice

To generate a meaningful and finely resolved database from the small number of simulated data points, we rely on spline interpolation. This method is based on piecewise polynomials that are smoothly connected between the existing points. This produces smooth, continuous curves that can provide accurate intermediate values both along the output pressure axis and with varying input pressure values.

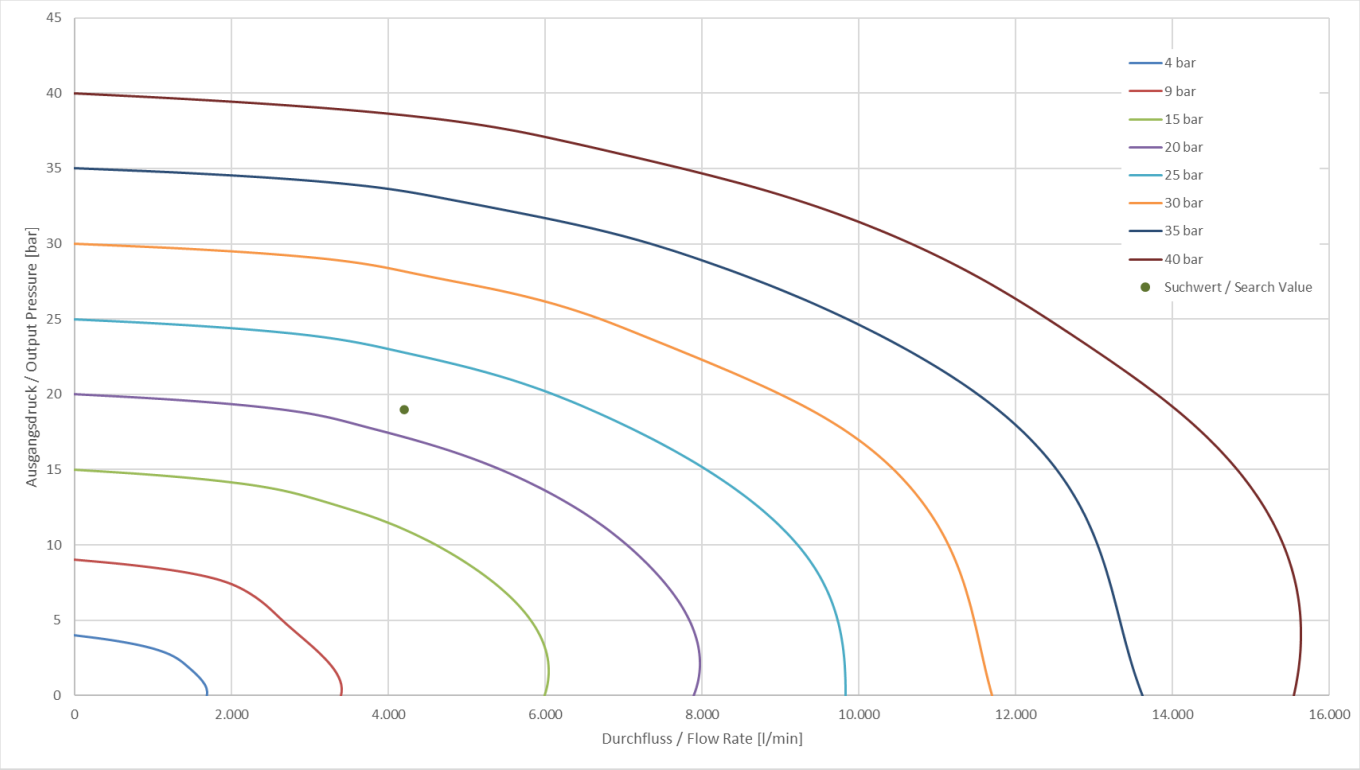

Figure 3: Characteristic curve field with flow values, using MLS Lanny G-valves as an example, based on spline interpolation.

To implement this method, we use Python, which allows for accurate and controlled calculation of the splines through the use of appropriate libraries. From this, we generate extensive look-up tables that map the flow rate in fine gradations depending on the outlet pressure for different inlet pressure levels.

In addition, we have developed another Python script that allows interpolation between these pre-calculated curves. This makes it possible to accurately determine the flow rate even for input pressure values that are not explicitly simulated. This technical basis forms the core of the planned digital tool, in which two of the three parameters - inlet pressure, outlet pressure, flow rate - can be entered and the third value is automatically determined.

Figure 3 shows a graphical example of the result. The curves shown are no longer based solely on the data points obtained from the simulation, but on the database determined by spline interpolation.

To illustrate the interpolation between the inlet pressure curves, the following search value is also shown graphically in Figure 3:
Inlet Pressure [bar]: 22
Outlet pressure [bar]: 19
Flow rate (l/min): 4,204

6 Summary

Starting with a few simulated data points, this white paper shows how mathematically clean spline interpolation can be used to create reliable map fields. This database allows not only accurate evaluation within the simulated input pressure levels, but also interpolation between them. The combination of look-up tables and Python-based curve interpolation creates the basis for digital tools that can be used flexibly and automatically in practical design in the future.

7 About MLS Lanny

MLS Lanny is a medium-sized company located in the Black Forest, Germany, specializing in the development and manufacture of control valves for industrial applications. Since the company was founded in 1994, our focus has been on technical excellence, customized solutions, and long-lasting product quality. Our high level of vertical integration at the site enables us to offer exceptional flexibility and delivery reliability.

Why We Are Your Ideal Partner

- **Collaborative Partnership** – We collaborate closely with our customers to develop tailored solutions and provide high-level service, even in the event of malfunctions. Thanks to our global distributor network, we are quickly and reliably accessible worldwide.
- **Sustainability & Durability** – Our valves are repairable, with long-term spare parts availability. We offer professional repair services – for a sustainable and cost-efficient lifecycle.
- **Customer- & Application-Specific Solutions** – A wide range of products, high flexibility in customization, support for various actuation types (including bus systems), and diverse mechanical connection options – precisely adapted to your needs.
- **Uncompromising Quality** – Precision and reliability are our top priorities – ensuring that our valves perform flawlessly even under extreme conditions.
- **The Best Control Valve on the Market** – Our valve design enables maximum precision and outstanding control performance – across the entire pressure range.

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