Accurate Tests in Vacuum

Tool for proprietary calibration and testing of vacuum gauges in the range from atmospheric pressure to ultrahigh vacuum

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As a manufacturer of vacuum measurement instrumentation and service provider for other producers' gauges we are regularly faced with the task of generating arbitrary vacua within a recipient and recording calibration values of the examined sensors. Four DAkkS-calibrated gauges serve as our references for pressure measurement over ten decades.

Mass flow controllers are rather inappropriate for setting any pressure, since each can only cover a dynamic range of one decade. Manually operated needle valves have disadvantages regarding hysteresis and repeatability and are not automatable.

To solve this problem we decided to utilize the all-metal-variable leak valve 590 from VAT (**Fig. 1**), which combines two distinguished characteristics: The excellent quality of VAT all metal valves, well known in XHV applications and large accelerator research, and the leading edge control technology, known from butterfly and gate valve systems in semiconductor and thin film production. With its hard-on-hard sealing diaphragm it enables pressure regulation for the whole vacuum range from rough vacuum to XHV while being simple to use and maintain.

Fig. 1 VAT 590 Variable leak valve with stepper motor drive

Our vacuum system is being evacuated pressure-dependently by scroll pump P1 and turbomolecular pump P2 down to about 10^{-7} mbar (**Fig. 2**).

Pressure control is divided into three ranges:

- One dynamic range with upstream control between 10^{-7} and 10^{-3} mbar at an effective pumping speed of 500 l/s; evacuation via V1,
- a second dynamic range with upstream control between 10^{-3} and 10^{-1} mbar at an effective pumping speed of 5 l/s; evacuation via V2, and
- a static range between 10^{-1} and 1000 mbar by means of gas inlet up to the desired pressure.

In the dynamic ranges between 10^{-7} and 10^{-1} mbar a computer-controlled voltage

$$U = 5\,\mathrm{V} + 1.25\,\mathrm{V} \cdot \lg \frac{p_{\mathrm{actual}}}{p_{\mathrm{desired}}}$$

is being generated continually based on the readings p_{actual} of the four calibrated gauges as well as the target value p_{desired}. This voltage is applied to the sensor input (0 – 10 V) of the VAT fine control valve. Thus, pressure regulation was decoupled from sensor characteristics and is no longer limited to one connected sensor. Regulation parameters (P and I gain) and the desired signal voltage of 5 V have to be sent to the valve's serial interface only once.

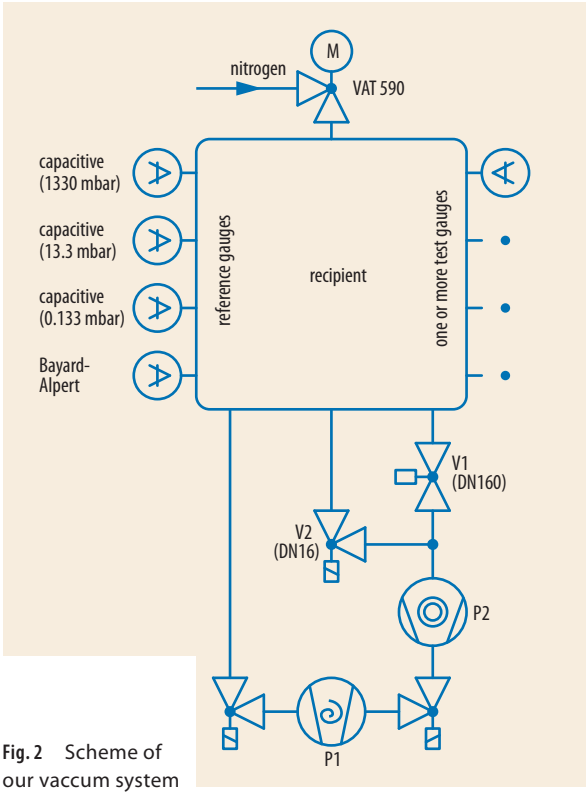

Fig. 2 Scheme of our vaccum system

When setting pressures between 10^{-1} and 1000 mbar, all valves to pumps are being closed and the fine control valve is being computer-controlled in position mode. As soon as the desired pressure is reached, this valve is also being closed. Contrary to a dynamic operation with simultaneous pumping and gas inlet, for this static operation only the essential amount of gas is consumed.

Figure 3 shows the chamber pressure over time for a showcase measurement series with one measuring point per pressure decade over the whole usable vacuum range. For each desired value the pressure was shortly held constant with an accuracy of one percent. The pressure drop to $6 \cdot 10^{-7}$ mbar at $t = 103$ s during the transition from the dynamic range for pressures $<10^{-3}$ mbar to the one

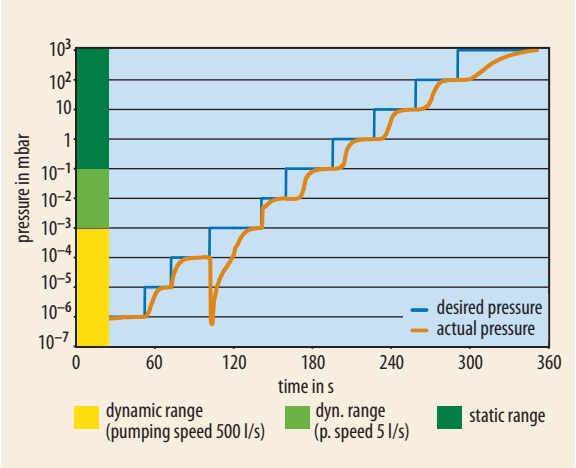

Fig. 3 Test series: pressure regulation over 9 decades.

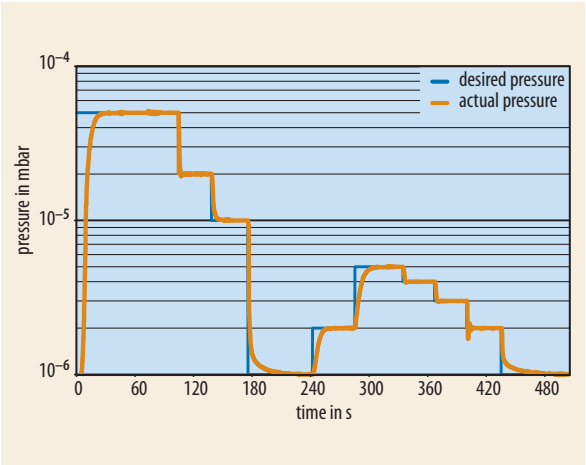

Fig. 4 Test series: stability of arbitrary pressures in high vacuum.

for pressures $\geq 10^{-3}$ mbar is caused by a precautionary closing of the control valve, which is necessary to counteract the sudden reduction of pump speed when V1 is being closed.

Exemplary, **figure 4** depicts the pressure stability in high vacuum for several values. In this measurement each pressure was kept constant for at least 30 seconds.

By utilizing the new fine control valve 590 from VAT in connection with an own LabVIEW software for the automated pumping station control and recording of measurement series we succeeded in facilitating proprietary calibrations and inspections of vacuum gauges as well as customer-specific measurements in the range from atmospheric pressure down to 10^{-7} mbar while operating resource- and time-saving. Achieving a pressure accuracy of less than one percent deviation from the calibrated reference sensors over the whole working range previously had only been possible with a considerably increased effort, especially in the high vacuum range.