

# Continuous Expansion

Dr. Karl Jousten

## Method

In the continuous expansion method, the pressure is reduced by two largely different conductances. The gas flows continuously from a volume at relative high pressure into the calibration chamber and thereafter to the vacuum pump.

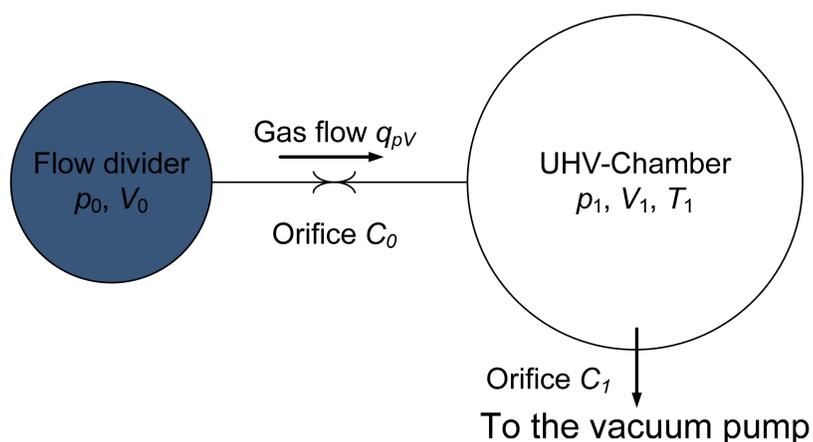


Figure 1: Scheme of the continuous expansion

The pressure  $p_1$  in the calibration chamber is given by:

$$p_1 = \frac{p_0 \cdot C_0}{C_1} = \frac{q_{pV}}{C} \quad \begin{array}{l} q_{pV} \text{ Gas flow} \\ C \text{ Conductance} \end{array} \quad (1)$$

## The Primary Standard CE-3

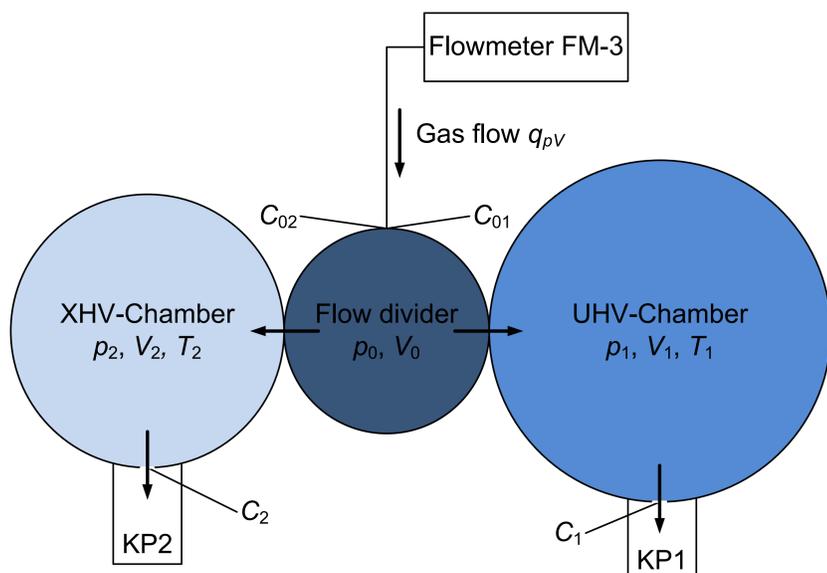
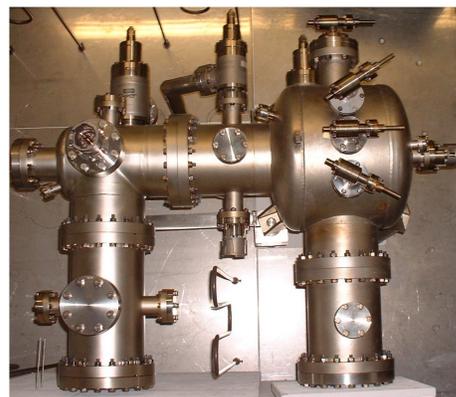


Figure 2: Scheme of the primary standard CE-3

At the PTB, pressures in the range  $10^{-10}$  Pa to  $10^{-2}$  Pa are generated by the primary standard CE-3, based on the continuous expansion method. This method was improved to enlarge the calibration range. For these

purposes two calibration chambers (UHV-chamber  $V_1$  and XHV-chamber  $V_2$ ) and two cryo pumps were used (Figure 2). Between these chambers a flow divider channels about 99% of the gas flow into  $V_1$  and 1% into  $V_2$ . Thus the gas flow in  $V_2$  will be about a factor 100 lower than in  $V_1$ . The gas flow  $q_{pV}$  is produced and measured by the flowmeter FM-3.



Cold surfaces at 2.6 K pump the gas molecules exiting from the two calibration chambers through the pump orifices. The high condensation probability of the gas molecules on these surfaces avoids

backstreaming for most gas species into the calibration chamber. As a result the orifices act as a "black hole" for the gas molecules. If both cryo pumps operate, the gas flow  $q_{pV}$  is subdivided into two gas flows into the respective chambers :

$$q_{pV} = q_{01} + q_{02} \quad (2)$$

If only cryo pump KP1 operates, the calibration pressure in volume  $V_1$  is given by:

$$p_1 = \frac{q_{pV}}{\gamma_1 C_1} \cdot \frac{\sqrt{T_{CH_1 T_0}}}{T_{FM}} \quad (3)$$

$T_{CH_1}$ Temperature of $V_1$	$T_{FM}$ Temperature of flowmeter
$C_1$ Conductance of orifice	$q_{pV}$ Gas flow rate
$\gamma_1$ Factor accounting back-streaming ( $\approx 1$ )	$T_0$ Reference temperature 23 °C

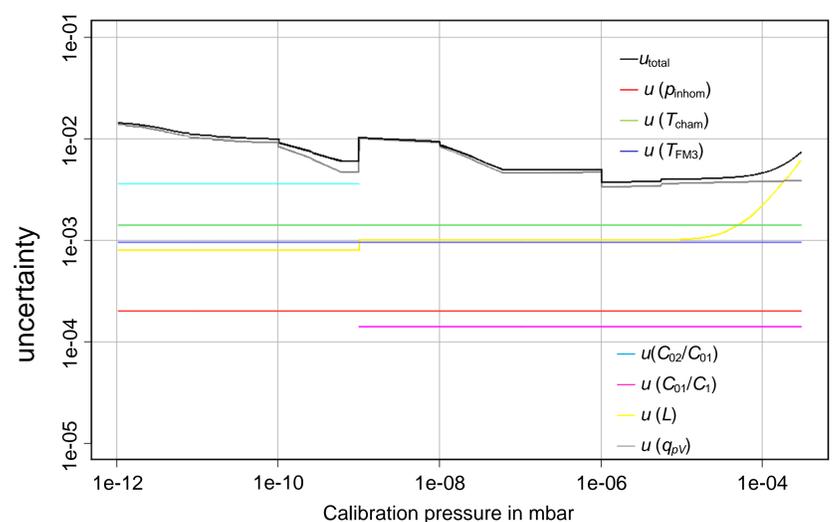


Figure 3: Uncertainty of generated pressure in CE-3

