CALCULATIONS OF TECHNICAL CAPACITIES OF THE TRANSMISSION SYSTEM OF NET4GAS

1. Technical capacity – volumetric flow rate

Technical capacity in general represents the maximum possible volumetric flow rateof real gas through the pipeline under given conditions. The technical capacity of the border point of the transmission system represents the maximum amount of gas per time unit which an operator is able to transfer from or into an adjacent transmission system. The volumetric flow rate (*hence* technical capacity) is affected by a number of parameters whose interrelations are described in the flow equation. Assuming gas is flowing constantly through a straight section of a pipe of the length L and diameter D – Figure 1. The difference of pressures at the pipe ends is p_1-p_2 (assuming $p_1>p_2$) and the average gas temperature is T.

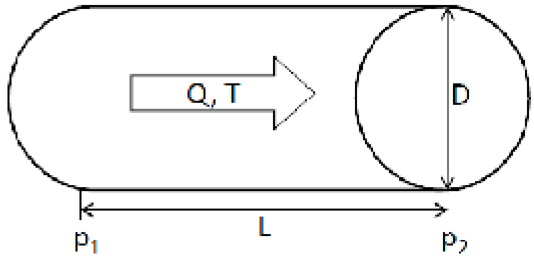

Figure 1

The flow equation, defining the gas volumetric flow rate value, can be derived from the law of conservation of momentum of flowing gas (continuity equation) and is as follows:

$$Q = K \cdot \left(\frac{T_b}{P_b}\right) \cdot \left(\frac{P_1^2 - P_2^2}{GTLZf}\right)^{0.5} \cdot D^{2,5}$$

where

Q – gas volumetric flow rate, measured at standard conditions
P_1,P_2 – pressure at the beginning and end of the pipeline
L – length of pipeline
D – diameter of pipeline
T – average gas temperature in the pipeline
T_b, p_b – temperature and pressure of gas under the reference conditions
G – gas gravity
Z – compressibility factor
f – friction factor
K - coefficient

The equation is still simplified and does not include the effect of the difference in altitudes at the two ends of the pipeline, but the influence of the individual parameters on the overall flow is evident from it.

2. Effects of the system organization and real elements on the technical capacity

2.1 Effect of domestic consumption

The pipeline leads from point A to point B and the offtake points for domestic consumption D_1 and D_2 are situated on it, as represented in Figure 2. It is necessary to secure minimum delivery pressures at these points. Defining technical capacity as the maximum possible Q coming out ofpoint B, we must make sure, when increasing the gas volumetric flow rate between A and B, that the pressure gradient is not too steep, so as to prevent a pressure drop below the delivery pressures at points D_1 and D_2. The technical capacity can thus be limited by the necessity to maintain minimum delivery pressures for domestic consumption and, of course, by the fact that the resultant capacity in point B depends on the distribution and amount of consumptions along the route between points A and B.

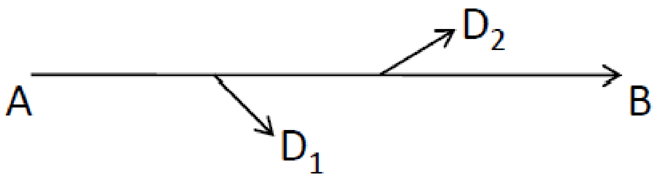

Figure 2

2.2 Effect of underground storage facilities

In the case of connecting an underground gas storage facility (UGS) to the line AB – see Figure 3, the UGS can fulfil the function of an offtake point (injection) or a delivery point (withdrawal) of gas, for which it is necessary again to maintain the minimum transfer pressure. Due to the withdrawal or injection of gas into the UGS, a different distribution of pressure and volumetric flow rate along the pipeline will occur, thereby affecting the volumetric flow rate at point B, i.e. the UGS facilities also have an impact on the technical capacity.

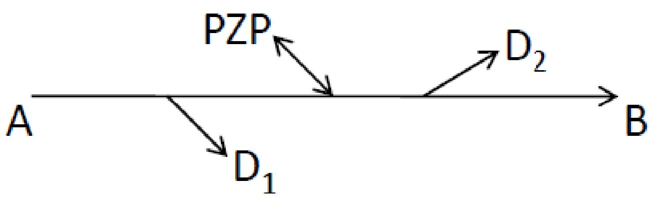

Figure 3

2.3 System configuration

The basic factor when calculating capacities is the system configuration itself. In the example below (Figure 4), it is theoretically possible to maximize the volume flow between B and C, but it is not possible to maximize the flow between B and D at the same time due to the limited technical possibilities of section AB.

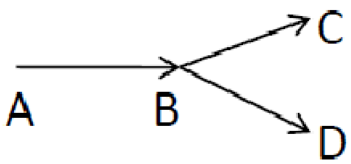

Figure 4

In these cases, to establish the flow distribution between sections BC and BD, it is necessary to draw on the customers' needs, the distribution of flows from the past years, the distribution according to the current transmission contracts and forecasts.

2.4 Real elements of the transmission system

Alongside the pipeline sections, the pipeline system contains other elements bearing on the resultant capacity:

- Section valves – serve the dispatchers to control the system, to shut down a section as a result of an accident or due to repairs, to change the configuration of the gas pipeline system, etc. Their own influence on the resultant capacity is rather small, they only effect a certain pressure drop.
- Regulation valves – serve to regulate the pressure or amount of gas going through a given point. They are an instrument enabling the dispatchers' control of the system or gas flow between pipelines with different MOP (maximum operation pressure level). When fully open, the pressure control valves exercise virtually the same influence as the line-valve stations.

Compressor stations – pressure drops caused by long-distance transmission of gas must be compensated for in order to secure the values of the delivery pressures at the border points and transfer points for domestic consumption or the UGS. To this end, compressor stations are installed to increase the gas pressure in the pipeline by means of compressor units, thereby allowing for its further transmission. The possibility to increase pressure is limited either by the maximum operation pressure of the pipeline at discharge of compressor or by the possibilities of the compressor itself and the power unit. These are defined by what is known as working characteristic and working point, which must be within the characteristic. An example of such a working characteristic is provided in Figure 5. The vertical axis represents adiabatic head ; the horizontal represents gas flow rate in the parameters at the compressor suction.

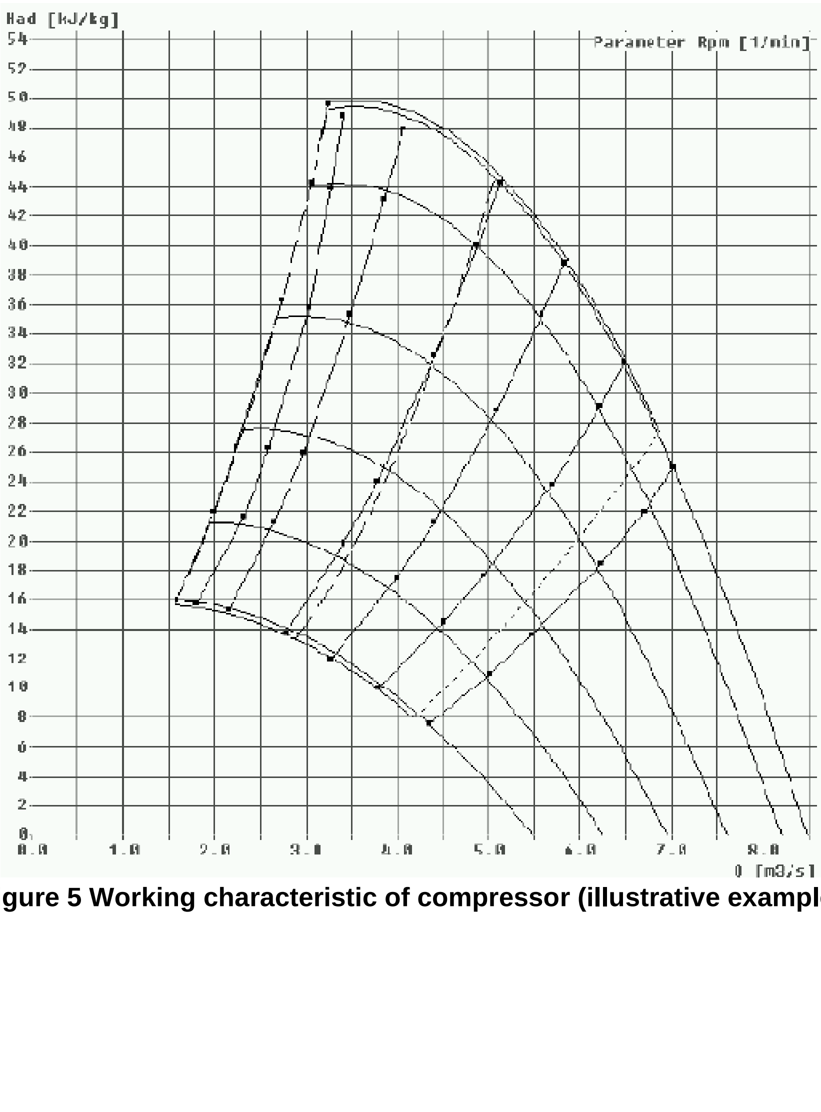

Figure 5 Working characteristic of compressor (illustrative example)

3. Defining technical capacities of the transmission system of NET4GAS

All of the above effects (influences) are allowed for in establishing technical capacities of the each point of the N4G system. SIMONE software is used for hydraulic calculations of the system. To simulate and optimize gas transmission and distribution, it uses a number of advanced numerical methods, such as the following:

- Implicit integration method – by progressive linearization, it safeguards the system against parametric oscillations;
- Decomposition method – by using the sparseness of the equation system matrix at minimum memory requirements and maximum calculation acceleration;
- Gradient method of hierarchical optimisation of dynamic systems – makes it possible to optimise stationary and transient phenomena

The entire transmission system and its parameters, that are critical for establishing two quantities in which we are interested most: pressure and volume flow in a given point, are modelled in SIMONE.

To establish the technical capacity of a given transfer point of the system, we proceed as follows:

I. We define worst-case scenarios regarding the transmission for each border point, i.e. the amount of domestic consumption and whether other border points consume or deliver gas. The TSO cannot influence these parameters.

II. Proceeding from the pressure conditions for each transfer point, we establish the maximum entry and exit capacities in the model by means of the best possible management of the system and compressor stations in the given transmission mode.

The resultant values must comply with the following:

- Any possible combination of transmission, which is made theoretically possible by the technical capacities, must be feasible.
- Transmission must be feasible at any offtake for domestic consumption.