Operational Experiences with Excess Flow Valves for Service Lines and Main Lines in Network Operation

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In co-operation between BEGAS -Burgenländische Erdgasversorgungs AG and Pipelife Austria GmbH. & Co. KG at first an "Excess Flow Valve" for service lines was developed in 1990-1991 (see also "GWF Gas • Erdgas Nr. 11 - 1994", page 628 - 635). Since 1992 this product is applied under the name "Pipelife Gas-Stop™" by gas-supply companies worldwide. From 1997 advanced Pipelife Gas-Stop™ types were also used for the protection of main lines and services for larger buildings. The great demands from the gas-supply field made on the materials, design and the quality assurance of the Pipelife Gas-Stop ™ have proven right. The reliable function in case of damage without any disturbance in normal operation supports this. 11 years of practical experience furthermore show that the demanded protection objectives were fully accomplished. With the further development of the Gas-Stop types for service lines to products that can be applied in main lines and services for larger buildings a full safety-system for the protection of distribution networks is now provided.

Introduction

Service Lines

In the year 1990, development work began at BEGAS - Burgenländische Erdgasversorgungs AG on a quick closing valve (excess flow valve) for service lines. Already in 1991 the first prototypes were successfully tested in practical network operations. The need for this safety equipment was based in the constantly increasing instances of digger damage to service lines and the associated risks and accidents – including personal injuries – caused by the uncontrolled leakage of gas.

In cooperation with the company Pipelife Austria GmbH. & Co. KG (hereafter referred to as Pipelife), the quick closing valve was further developed for industrial series manufacture. A pilot run of 1000 units produced in 1992 was installed in the BEGAS supply region already during the same year. After the positive result of this field test, series production of the quick closing valve began in 1993 and the product was put onto the market with the brand name Pipelife Gas-Stop™ (hereafter referred to simply as Gas-Stop).

Currently, approximately 2.0 million Gas-Stop units for service lines are installed in Europe and overseas.

Main Lines

In 1996 planning of a regional gas supply network for 24 smaller communities was begun at BEGAS. Profitability calculations performed during the course of the planning showed that an expansion with the conventional construction techniques, i.e. with high pressure pipe system PN70 and gas reducing stations in every community would not be economically feasible. It was therefore decided to expand into this region with a medium pressure system of PE pipes at a maximum operating pressure of 4 bars. Main lines and service lines even in the communities themselves were designed for an operating pressure of 4 bars. With this supply technology, it was possible to reduce the investment costs by 35% compared with the conventional system. This made the expansion economically feasible.

However, this project was also the motivation for the development of Gas-Stop types for the installation in main lines for the following reasons:

- At operating pressures up to 4 bars, very large quantities of gas escape in the event of damage to main lines. This leads to significant accident risks, particularly in populated areas.
- Due to the constantly increasing traffic volume, the arrival times to the damage site could far exceed 30 minutes and the expansion of the supply area also made the travel distances longer.
- During the escape of large quantities of gas, the pressure drop in the pipe network can reach an extent at which gas supply failures occur over a large area or measurement equipment in pressure regulation systems can be destroyed.

Since 1997, BEGAS has now secured main lines in the pressure range > 100 mbar with Gas-Stop units. In Austria and other European countries, approximately 2,000 of these Gas-Stop units have been installed in main lines and put into operation to date. Gas-Stop is currently being manufactured for installation in main lines with the dimensions DN50 - DN150 and for operating pressures up to 10 bars. These Gas-Stops are also used for securing building service connections – e.g. public buildings, hospitals, production plants, etc.

Gas-Stop in Service Lines
12 Years of Experience at BEGAS

Product Introduction in Network Operation

After successful completion of the field test in the year 1992, it was decided to equip and secure every newly constructed service line as of April 1, 1993 with Pipelife Gas-Stop™. BEGAS operates pipe networks of PE as well as steel in the pressure levels up to ≤ 100 mbar, ≤ 1 bar and ≤ 4 bar (company-internal designations ND, MD1, MD4).

The minimum pressures both for the pipe network calculation and for the operation of the networks are 35 mbar for ND, 300 mbar for MD1 and 2 bars for MD4. This decision is also decisive for the dimensioning of the service line and the selection of the Gas-Stop type because the nominal flow and the shut-off flow for the Gas-Stop depend on the operating pressure.

In determining the minimum pressure in ND networks, it was considered that the Gas-Stop causes an additional pressure loss. The meter pressure regulator requires at least an input pressure of pa (initial pressure) + 4 mbar. The determination of the minimum pressure is shown in the table below using a PE service line da32 and a nominal flow of 10m³/h as an example.

Meter regulator pa + 4 mbar	22.0 mbar + 4.0 mbar =	26.0 mbar
Pressure loss of pre-meter line, length 10 m (steel k = 0.1) without individual resistances		1.6 mbar
Pressure loss of service line., length20m (PE da32, k = 0.05) without individual resistances		1.4 mbar

Pressure loss of Gas-Stop	2.5 mbar
Pressure loss of tapping saddle*	2.5 mbar
Total:	**34.0 mbar**

Table 1: Determination of the minimum pressure
* Possible maximum value. Depending on the product, the pressure losses generally lie below this value.

The minimum pressure was internally set at 35 mbar to also allow for compensation of any losses from individual resistances.

At that time, 3 dimensions of service lines of PE, specifically da32, da50 and da63 were installed in ND networks as well as in MD1 and MD4 networks at BEGAS. This also meant that 6 Gas-Stop types were required. In 1996, the construction of service lines in the dimension da50 was ceased, which reduced the number of Gas-Stop types to 4. This proved to be advantageous from a logistical perspective and for technical application reasons.

The introduction phase was also significantly simplified by the fact that the nominal flows of the Gas-Stop types in the ND range were adapted to the meter sizes G6, G16 and G25. The simple identification of the various types was ensured through the colored type labels and the additional labeling of the pressure range. Blue type labels were used for the ND range and red for the MD range.

Sample type designation:

GS32/25 (blue type label)

Gas-Stop for installation in a PE service line da32; pressure range > 25 - ≤ 100 mbar minimum operating pressure 25 mbar. (Pipelife Gas-Stop ™ units for the pressure range > 25 - ≤ 100 mbar are also designated as type A according to DVGW VP 305-2.)

Image 1: Pipelife Gas-Stop ™ types GS50/25, GS63/25, GS32/25 (left to right)

GS 63/150 (red type label)

Gas-Stop for installation in a house service connection PE da63; pressure range > 100 mbar - ≤ 5 bar, minimum functioning pressure 150 mbar. (Gas-Stop units for the pressure range > 100 mbar - ≤ 5 bar mbar are also designated as type B according to DVGW VP 305-2.)

Image 2: Gas-Stop type GS63/150

In determining the meter size, both the dimension of the service line and the Gas-Stop type are also determined. At the construction site, one must therefore only make certain that a Gas-Stop with a blue type label is installed.

Type	Vn [m³/h]	For meter sizes
GS32/25	10	G2.5 - G6
GS50/25	25	G10 and G16
GS63/25	40	G25

Table 2: Nominal volume flow (Vn), meter sizes for the pressure range > 25 - ≤ 100 mbar

Studies have also been performed in other gas supply companies on the determination of the nominal flow rates in the pressure range > 100 mbar - ≤ 5 bar in order to achieve solutions that appropriately meet the specific requirements. Analysis of the studies showed that the requirements could largely be fulfilled with the nominal flows according to table 3.

Pipe network pressure bar	GS32/150 Vn [m³/h]	GS50/150 Vn [m³/h]	GS63/150 Vn [m³/h]
0.15	22	57	85
0.3	23	60	90
0.5	25	65	97
1.0	29	75	112
2.0	35	92	137
3.0	41	106	159
4.0	46	120	180
5.0	50	132	200

Table 3: Nominal volume flow (Vn) for the pressure range > 100 mbar - ≤ 5 bar

The 12 years of practical experience have shown that the requirements are met in BEGAS as well as in other gas supply companies with only a few exceptions.

These exceptions involved Gas-Stop types of the dimension da63, where higher nominal flows than given in Table 3 are required for the connection of buildings with very high consumption volumes. For such cases, a Gas-Stop type has been developed that has a nominal flow rate roughly twice that of the GS63/150.

Operating Experiences

Damage Statistics

Since April 1, 1992, a total of 26.399 Gas-Stop units have been installed in service lines at BEGAS. Not a single supply disruption due to a Gas-Stop has yet occurred.

As of October 30, 2004, 184 instances of damage or improper handing on Service lines secured in this way have been recorded. In detail, these instances were

Digger damage	158	85.9	%
Inside leaks	7	3.8	%
Improper handling	12	6.5	%
Manipulations	0	0.0	%
Damage too small (Gas-Stop ™ did not close)	7	3.8	%
	184	**100**	**%**

In 177 instances, the Gas-Stop performed its proper function and closed, i.e. in 96.1% of the house connections equipped with Gas-Stop, a leak was prevented.

In 7 cases, Gas-Stop was also able to prevent leaks inside buildings. In 3 of these cases, pre-meter lines without adapters were drilled into with 8 or 10 mm drills; 4 cases were attributed to improper work on the consumer systems.

The 12 improper handlings listed above can be attributed to excessively rapid bleeding during the startup of new service lines. If the main shut-off device is not opened at the appropriate measured rate during this bleeding process, the closing flow of the Gas-Stop escapes, causing it to close. To prevent this possible operational error, training measures were performed already during the introduction phase and additional notices with the text “Gas-Stop installed” were placed in the vicinity of the main shut-off device.

In 7 cases, the damages to the Service lines were too small, meaning that the volume required for the Gas-Stop to close could not escape.

Protection Goal, Protection Range

In 1991, it was defined as the protection goal that the Pipelife Gas-Stop ™ should close upon a full tear at the end of a 50 m long service line at the respectively defined minimum operating pressure. As previously mentioned, the minimum operating pressures at BEGAS are set at 35 mbar in ND networks, 300 mbar in MD1 networks and 2 bar in MD4 networks. However, practice has shown that even significantly smaller damages to the service lines have led to closing of Gas-Stop units.

Within the scope of a project of the ÖVGW (Austrian Gas and Water Association) for identifying and quantifying the methane emissions of the Austrian gas industry, BEGAS was entrusted with the project component for the area of local gas supply. Among other resources, the scientific support of the Mining and Metallurgy University of Leoben was obtained. Because a significant portion of the methane emissions can be attributed to digger damages, it was necessary to measure the corresponding leakage volumes on actually damaged pipeline sections. (Note: through the use of Gas-Stop units in the BEGAS local gas supply, it was possible to reduce the methane emissions by 26%.)

In the year 1999, a total of 45 service lines of PE da32 were damaged during excavation work. The damaged pipe sections were removed and the leakage volumes measured in an appropriately equipped measurement system. The size of the damage and the escape value were also determined.

The results of the analysis of the previously mentioned 45 damage instances with regard to the damage size, leakage area and escape value are summarized in the Tables 4 and 5 below.

Number	Leakage Area [mm²]	Cross-Section Damage [%]	Diameter* [mm]
7	> 20 - ≤ 100	3.8 - 18.9	5.0 - 11.3
9	>100 - ≤ 200	18.9 - 37.7	11.3 - 16.0
9	>200 - ≤ 300	37.7 - 56.5	16.0 - 19.5
12	>300 - ≤ 400	56.5 - 75.4	19.5 - 22.6
8	>400 - ≤ 504	75.4 - 95.0	22.6 - 25.3

Table 4: Leakage areas – damage sizes

* Leakage area converted for the comparison diameter

Number	Escape Value	Frequency [%]
10	0.3 - 0.5	22.2
28	0.5 - 0.7	62.2
7	0.7 - 0.9	16.6

Table 5: Escape values, frequency distribution

Table 4 shows that not a single complete tear occurred. Only a single damage instance had a leakage area of 504 mm², which corresponds roughly to 95% cross-section damage.

Based on these statistics, the protective effect and also the possible protection range can be described in more detail than was possible in 1991. The protection range is the pipe length after the Gas-Stop within which the Gas-Stop closes in the event of damage.

Table 6 below shows the protection ranges for various damage sizes with respect to a pipe network pressure of 35 mbar and an escape value of 0.6, using a PE service line da32 equipped with a Gas-Stop with a closing flow 18.5m³/h as an example.

Leak [mm]	Cross-Section Damage [%]	Protection Range [m]
12.0	21.3	10
12.5	23.1	20
13.5	27.0	30
15.5	35.6	40
17.0	42.8	50

Table 6: Damage sizes, protection ranges for a PE service line da32 secured with a Gas-Stop, network pressure 35 mbar

For higher operating pressures, smaller damages than those shown in Table 6 are already sufficient to cause the Gas-Stop to close and longer protection ranges are also possible.

In the pressure range >100 mbar, for example at a minimum network pressure of 300 mbar, and a PE service line da32 secured with a Gas-Stop with 35m³/h closing rate, the Gas-Stop still closes when a leak of 10 mm occurs 100 m after the Gas-Stop or if a leak of 13 mm occurs 200 m after the Gas-Stop . In other words, very long protection ranges are possible in the pressure range > 100 mbar - ≤ 5bar, whereby service lines with lengths > 100 m are rare. It is therefore most significant that in this pressure range, smaller damages cause the Gas-Stop t close than in the pressure range < 100 mbar.

Due to the results of the leak rate measurements performed as well as the determination of the damage sizes and escape values, a more precise definition of the protection ranges was now possible. A definition of the protection range at the minimum functioning pressure of the Gas-Stop (e.g. 25 mbar) and the assumption of a complete tear was not at all appropriate. Generally the operating pressures in a low pressure network (eND) during normal operation are higher than 25 mbar (see also Table 1, page 2) and full tears hardly ever occur in practice (see also Table 4, page 6).

Contamination Influences

One important operating experience with Gas-Stop is that to date no functional disruptions have occurred as a result of contamination. For example, Gas-Stop units have also been installed in the steel pipe network of the city of Eisenstadt. These Gas-Stop units were randomly removed and subjected to a visual inspection for possible dust deposits. Then a functional test was performed on a test bench.

In the visual inspection, traces of microscopic dust could be found in some cases, however these had no effect whatsoever on the functional parameters in the subsequently performed functional test. Neither the seal nor the function of overflow mechanisms was impaired by the microscopic dust.

Operational Suitability Test by the GASWÄRME-INSTITUT e.V. Essen (GWI)

Within the framework of the DVGW study “Evaluation of Excess Flow Valves for Manipulation Difficulties” the GWI performed functional tests on Gas-Stop units in the supply region of BEGAS and Ruhrgas AG in northern Bavaria in summer of 2001. The functional capability after multiple years of operation in networks of various raw materials was tested.

The investigation parameters were:

- Actual shut-off flow compared with the target shut-off flow range (min/max) according to manufacturer information.
- Evaluation of the seal in the closed state.

The Gas-Stop units were not removed for the measurements. The pre-meter line was flanged off from the main shut-off device and a flow measurement device and seal testing device were installed. The flow was then increased with a corresponding blow-through line until the Gas-Stop closed and the measurement value at the time of closing was saved. Then the seal and overflow rate were measured. 7 units each were tested as described above at BEGAS and at Ruhrgas AG.

The respective test specimens were installed in the years 1992 to 1996 both in steel pipe networks and in PE pipe networks. The tests showed that all 14 Gas-Stop units fulfilled the functional parameters unchanged even after years of operation.

International Operating Experiences

Since 1992, approximately 2.0 million Gas-Stop units are now in use in Europe and overseas in pipe networks of PE, steel or cast iron with various operating pressures and gas qualities.
In more than 4,000 instances (as far as statistics are available), the Gas-Stop units have fulfilled their intended function and closed after damage to service lines. In only a single case was a

supply disruption caused by a Gas-Stop, and the cause for this was a faulty O-ring that had separated from the seal seat.

Long-term Experiences with Materials, Design and Quality Assurance

The operating experiences show that the Gas-Stop is an absolutely reliable and proven product. This can also be attributed to the fact that the requirements and established principles placed on the materials, design, function and quality assurance in 1991 have been strictly upheld and implemented.

Materials

It was established as an important principle that the materials for the Gas-Stop could not become the weakest link in the resistance chain of a PE pipe gas network. It had to be ensured that the long-term resistance to natural gas and its attendant substances corresponded at least to the pipe material PE and that the excess flow valve used requires no maintenance.

The same requirements on the material were naturally also placed on the most important component, the spring. During the course of selection of a material to meet the requirements, the scientific assistance of the Mining and Metallurgy University of Leoben was once again obtained. In particular, it had to be considered that, in accordance with the regulations ÖVGW G31 and DVGW G260, up to 150 mg of sulfur per 1 m³ of natural gas could occur in fault instances, meaning that sulfurous acids could form in the presence of moisture.

It was initially planned to manufacture the flow piece and closing element of metal materials. In order to meet the requirements listed above, it would have been necessary to manufacture these parts at least of stainless steel to prevent any risk of corrosion. However, use of this material would have been associated with very high costs, so alternatives were sought. Finally, the material polyphenylene sulfide (hereafter referred to as PPS) was selected. PPS is processed with injection molding and is even superior to the pipe material PE in some aspects of resistance and service life. This material as creepage-resistant, wear-resistant, stable up to 240°C and absolutely resistant to natural gas and its attendant substances. In addition, PPS is not attacked by any currently known solvents at temperatures $\leq$ 200°C.

For the most important functional part, the spring, stainless steel of material no. 1.4539 is used. This material is corrosion-resistant, has outstanding long-term properties and is antimagnetic. In addition, the Institute for Metallurgy of the University of Leoben was commissioned with developing a time acceleration testing process to appropriately confirm the sufficient resistance to corrosion and the long-term properties. The requirements, tests and results are summarized in Table 7 below.

Requirements	Tests	Results
Resistance to stress crack corrosion		
Chlorine and hydrogen-induced	Salt spray test at least 500 h as per ASTM B117	No cracks identifiable as a result of stress crack corrosion
Corrosion stress		
No crack formation under plastic elongation and surrounding with H_2S and CO_2	Stress until plastic elongation while surrounded with test gas (480 h) H_2S CO_2	At 50 times magnification, no cracks identifiable, no corrosion or damage from hydrogen

	CH_4 Additional elongation by 50%; microscopic examination for crack formation	
Fatigue resistance		
No tension loss or damage under dynamic loads	10^7 load changes at 6.5 Hz	No damage or tension loss identified
Endurance limit		
The long-term transverse strain amplitude must be > the actual one	Metallographic examinations and hardness testing; simulated determination of the transverse strain amplitude	Long-term transverse strain amplitude 200 Mpa actual 25 MPa

Table 7: Requirements, tests and results on the long-term properties of Gas-Stop springs

Design
The Gas-Stop consists of the housing, flow piece, closing element, spring and seals. The following principles were used as the basis for the design:

- No deposits in the direct inflow area
- Aerodynamic design of the inflow part of the closing element
- Aerodynamic design of the outflow part of the flow piece
- Seal element of the closing element not in the direct area of flow
- Option for installation in the outlet of tapping saddles, electrofusion couplers, directly in PE gas pipes or in welded-on adapters of the materials PE or steel
- Design with or without overflow mechanisms based on VP 305-2.

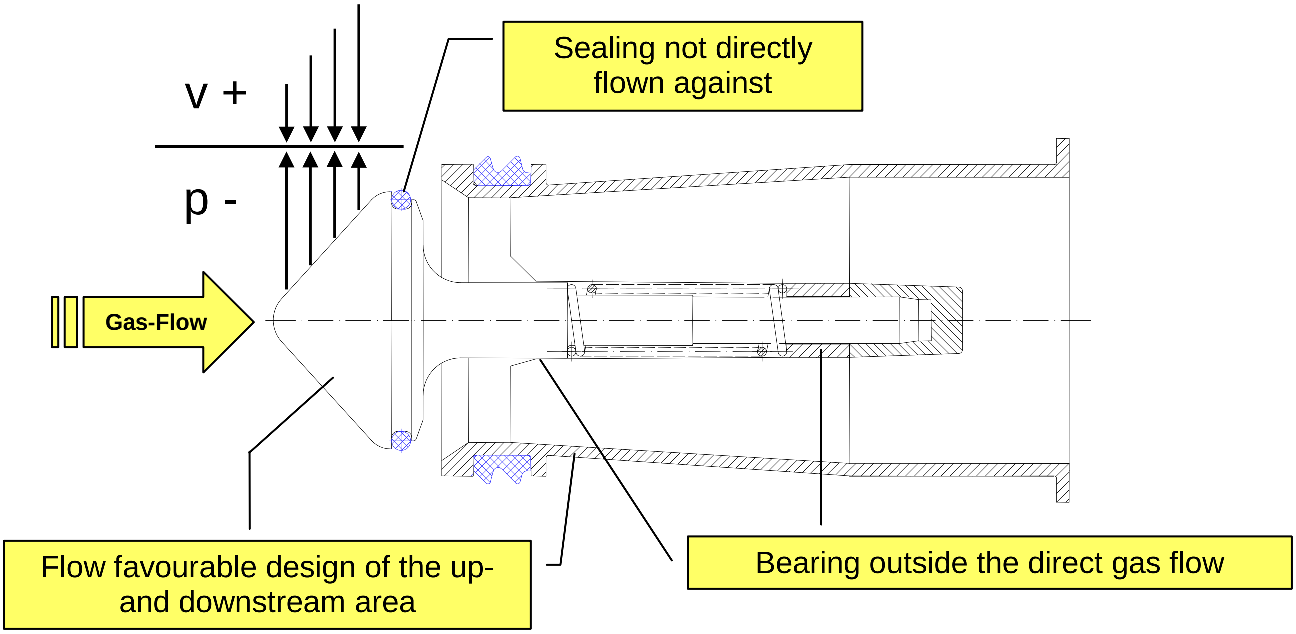


Image 3: Design features

The principles for the design of the Gas-Stop are based on the fact that microscopic dust can arise in gas pipe networks. However, the functional capability may not be limited even after years of operation. For this reason, no bearing of the closing element is situated in the direct area of flow. The aerodynamic design of the closing element and flow body prevents turbulence and therefore dusts deposits to the greatest extent possible.

Tests performed with iron oxide in powder form ($10cm^3/10m^3$ natural gas) have confirmed that the play of the closing element was not impaired and no dust deposits were identified in the flow piece.

Quality Assurance Requirements

Assuring the proper functioning of a Gas-Stop during subsequent network operation is part of the manufacturer's responsibility. A Gas-Stop must never close during normal operation but must reliably close according to the assigned closing parameters in the event of damage.

This high level of reliability is achieved through tests in which both the individual components as well as the end products are subjected to appropriate test processes within the framework of a certified quality assurance process.

One of the most important test steps is the functional inspection before shipment. The closing flow and seal of each individual finished product is measured and recorded on a fully automated test bench. The test result is documented on the product itself through the assignment of a serial number. All test results on the individual components are also associated with this seal number, ensuring seamless traceability.

The test bench for the functional tests described above was developed in close cooperation with ABB-Automationstechnik. The current test step can be observed online at any time by the operator of the system on a display screen. In addition to the actual sequence of the test, Figure 4 below also shows what additional data is collected for each individual product.

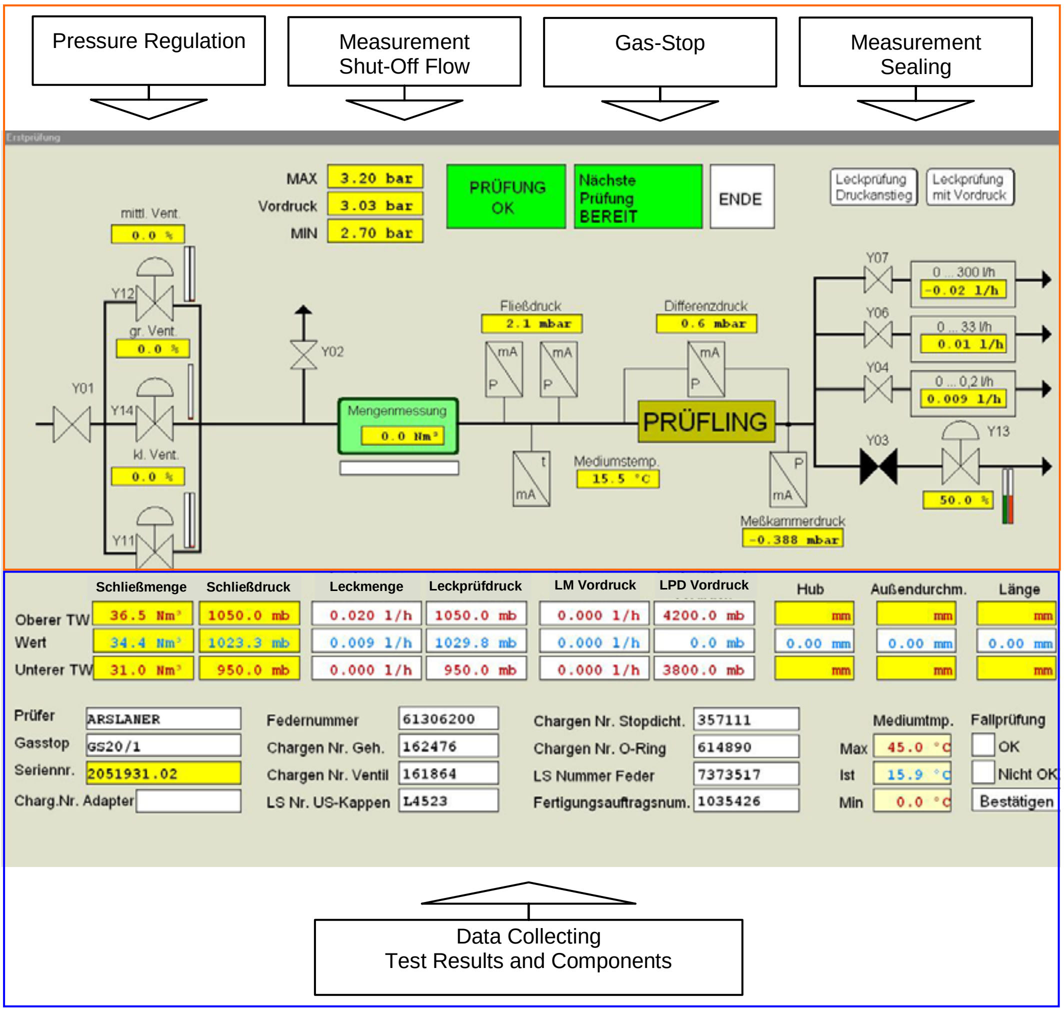


Figure 4: Gas-Stop system testing scheme (Source: Pipelife Austria)

To guarantee reliable functioning during normal operation as well as upon closing in a practical operating situation, the products are also tested on a natural gas test bench on the basis of a quality plan. This system is also used for simulating practical conditions for the development and further development of Gas-Stop products.


Figure 5: Natural gas test bench

6 Years of Experience with Gas-Stop in Main Lines

Product Description

In the development of the Gas-Stop types GS63/300, GS110/150 and GS110/300 for installation in main lines of the dimensions PE da63 – da160, the same principles and requirements were placed on the materials and design as for the Gas-Stop types for service lines. Because the pipe material PE100 makes it possible today to construct pipe networks for operating pressures up to10 bar, the Gas-Stop units were designed such that they could be used at this operating pressure.

The Gas-Stop type GS63/300, with a minimum functional pressure of 300 mbar, is also intended for installation in PE pipes of da90.

The Gas-Stop ™ types GS110/150 and GS110/300 with the minimum functional pressures of 150 mbar and 300 mbar are intended for installation in PE pipes of the dimensions da110 and da160. PE100 pipes are used as the housing. When installed in the pipe system,

PE da110 are installed with electrofusion couplers
PE da160 are installed with reducers

Mesh screens are installed in the input and output sides of the housing to protect against dirt. The mesh width of the dirt screen is smaller than the opening of the valve seat, which prevents large dirt particles from entering the valve seat – dirt particles smaller than the mesh width are transported completely through the valve seat by the flow.

The determination of the nominal flows for the respective Gas-Stop types took place based on the ÖVGW testing regulation PG494 “Quick Closing Valves“, in which the minimum nominal flows are defined. The requirements for closing flow, pressure loss, seal and overflow rate are also defined in PG494. The most important data for nominal flow and pressure loss are given in Tables 8, 9 and 10 below.

Operating Pressure [bar]	Nominal Flow [m³n/h]	Pressure Loss [mbar]
0.3	200	25
1.0	250	25
5.0	450	25
10.0	630	25

Table 8: Nominal flow, pressure loss GS63/300

Operating Pressure [bar]	Nominal Flow [m³n/h]	Pressure Loss [mbar]
0.15	410	25
1.0	550	25
5.0	850	25
10.0	1030	25

Table 9: Nominal flow, pressure loss GS110/150

Operating Pressure [bar]	Nominal Flow [m³n/h]	Pressure Loss [mbar]
]0.3	470	30
1.0	630	30
5.0	1245	30
10.0	1790	30

Table 10: Nominal flow, pressure loss GS110/300

The type series for Main Lines is equipped with an overflow mechanism. According to the requirements of the ÖVGW regulation PG494, the overflow rate may not exceed 1m^3/h at the maximum operating pressure. For building connections, the type series can also be designed without overflow mechanism.

Figure 6: Gas-Stop ™ for Main Lines da110 in a housing of PE100

Materials

The components of the GS63/300 consist of the same materials as those for the Gas-Stop products for service lines. In the type series GS110, the flow body and closing element components as well as the dirt screens are designed of stainless steel, material no. 1.4301. This meets the requirements of ÖVGW - PG494 that metallic components for quick closing valves (Gas-Stop units) must be made of stainless steel as per EN 10088-1 of at least material no. 1.4301.

Application Technology, Protection Goals, Protection Range

During the course of the planning of gas pipe networks, the shut-off sections in the respective gas pipe network are also defined according to internal company rules. This determines the number of required network shut-off valves and their installation locations. Various perspectives are considered in the definition of the shut-off sections, including which network sections should be shut-off in the event of damage.

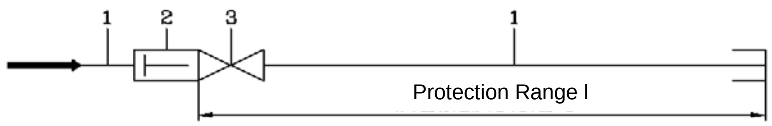
If one installs network shut-off valves and Gas-Stop units for main lines together, this causes the Pipelife Gas-Stop ™ to close after the occurrence of damage, preventing larger gas leaks. This achieves the primary protection goal because the corresponding network section is automatically shut-off without waiting until after the service team arrives at the damage location and operates the network shut-off valves.

Viewed in the direction of gas flow, these Gas-Stop units are installed before the network shut-off valves. Before starting repair of the damage, the valve should be closed. Due to the overflow hole integrated into the Gas-Stop, the pressure balancing occurs between the Gas-Stop and the pipe section up to the network shut-off valve – i.e. the Gas-Stop opens automatically.

It has proven itself useful in practice to design the pipe section between the Gas-Stop and the network shut-off valve as short as possible because this reduces the reopening times.

It should be noted that the nominal flow of the Gas-Stop depends on the operating pressure of the pipe network at the installation site. In addition, the length of the protection range also depends on the operating pressure, in other words, the length of pipe after the Gas-Stop within which the Gas-Stop will close in event of a certain damage size. For example, at an operating pressure of 3.5 bar, a Gas-Stop type GS110/150 closes if damage occurs to the pipeline approx. 2 km after the Gas-Stop with damage a size corresponding to a circular cross-section of 50 mm.

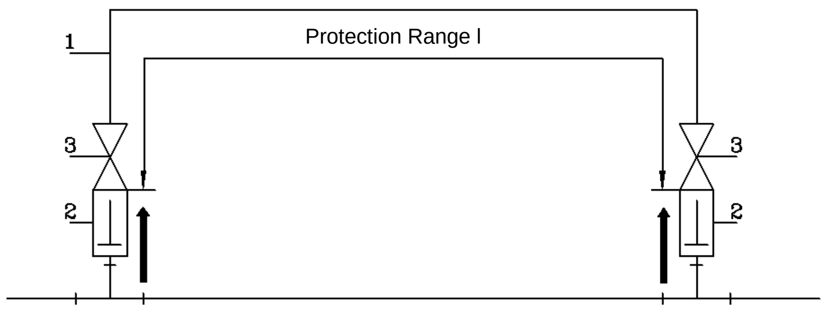
Pipe PE da110, pe = 1 bar, k = 0.3



GS110/150 l = 1.030m
GS110/300 l = 620m

1. PE pipe da110
2. Pipelife Gas-Stop ™ GS110
3. Shut-off element DN100

Ring line PE da 110, pe = 3 bar, k = 0.3



GSA110/150 l = 2.740m
GSA110/300 l = 1.520m

1. PE pipe da110
2. Pipelife Gas-Stop ™ GSA110
3. Shut-off element DN100

Figure 7: Example of protection ranges based on a damage size of 50 mm

Field Tests, Operating Experiences

In addition to the Gas-Stop types for service lines, Gas-Stop units for main lines are also currently installed at BEGAS, EVN-Energieversorgung Niederösterreich AG and Steirischen Gas-Wärme GmbH. in medium pressure networks. Corresponding projects are also planned at Wiengas.

Numerous field tests in medium pressure networks were performed at the above-mentioned gas supply companies. These had the goal of evaluating the reliable closing of the Gas-Stop at the respective operating pressure and for specific damage sizes within the protection range. In all tests, the calculated values for the length of the protection range were confirmed.

In order to allow for continuous inspection of the functioning of the Gas-Stop as well, a 3.2 km long main pipeline section at BEGAS in a local gas network with an operating pressure of 3.5 bar and secured with a Gas-Stop of type GS110/150 was adapted such that the closing as well as reopening could be inspected at regular intervals. The leak simulation is performed with a blow-out line installed at the end of the pipe section. After 20 tests performed to date, no changes to the functional parameters have been identified.

Since 1997, BEGAS has built a total of 33 local gas networks in which both the services and mains are secured with Gas-Stop . Since then, 2 main lines have been damaged by diggers in these networks. In both cases the installed Gas-Stop units closed and the shut-off sections were without pressure after a few minutes. The internal company decision to install Gas-Stop for main lines in the medium pressure networks of BEGAS has been confirmed as correct by these two damage instances. In both cases, it would have taken approx. 1 hour before a service team arrived at the respective damage site.

The 6 years of operating experience have shown that the Gas-Stop types for main lines function reliably and do not cause any operating disruptions. Contamination with dust and dirt also has no influence on the function thanks to the structural design of the Gas-Stop and the use of dirt screens.

Summary

The many years of positive operating experiences with Gas-Stop units at BEGAS and in numerous other gas supply companies show that these excess flow valves are absolutely reliable. This reliability can be attributed to the fact that fundamental requirements from the perspective of gas supply were considered in the selection of the materials, the design and the definition of the quality assurance processes. Among other requirements, this safety device was designed to require no maintenance and to remain functional over a period of at least 50 years. The experiences to date indicate that this will in fact be the case.

The specified protection goals were met to a very high degree. Naturally it simplifies the operational management in the gas supply company if no gas escapes in the event of damage; particularly if the travel times to the damage site could be up to one hour.