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“LINE BREAK”

AUTOMATIC DEVICE
FOR VALVE CLOSING
IN CASE OF GASLINE BREAKING

DT 5005 E

INDEX

1. Introduction

On the gaslines it is necessary to provide automatic safety devices, to close the valves in case of breaking of the pipeline, to stop the gas losses, which could create damages for the people, for things and economic damages.

The breaking of the pipeline causes a rate of pressure drop, depending on various factors, mainly as follows:

- diameter and length of the pipeline
- dimension of the break
- temperature and pressure of the gas
- flow rate
- distance from the breaking point to the valve on which the actuator, complete with "LINE BREAK" device, is assembled: the longer the distance is, the less is the pressure drop rate acting on the "LINE BREAK" device.

Also during the normal operation of the gasline there are pressure drop rates caused by changes in the compression stations operation or by increased gas quantities, required by branches and users.

A very reliable way to identify the breaking of the pipeline is to detect the "abnormal" value of the rate of pressure drop (DP/DT), exceeding the normal values verified during the normal operation of the pipeline.

The BIFFI "LINE BREAK" device, for the automatic valve closing in case of gasline breaking, is based on the principle to detect the pressure drop rate (DP/DT) by measuring the pressure difference between the reference tank and the pipeline, being the reference tank connected to the line through a calibrated orifice.

The device can be easily set to meet the dimensional and operating features of gasline.

The system does not need any external power source and uses only the gas of the pipeline.

For the setting of the device we must consider the minimum rate of pressure drop caused by the breaking of the line (which must assure the operation of the "LINE BREAK" device) and the maximum rate of pressure drop originated during the normal operation (which has not to cause the "LINE BREAK" device operation).

2. Working principle

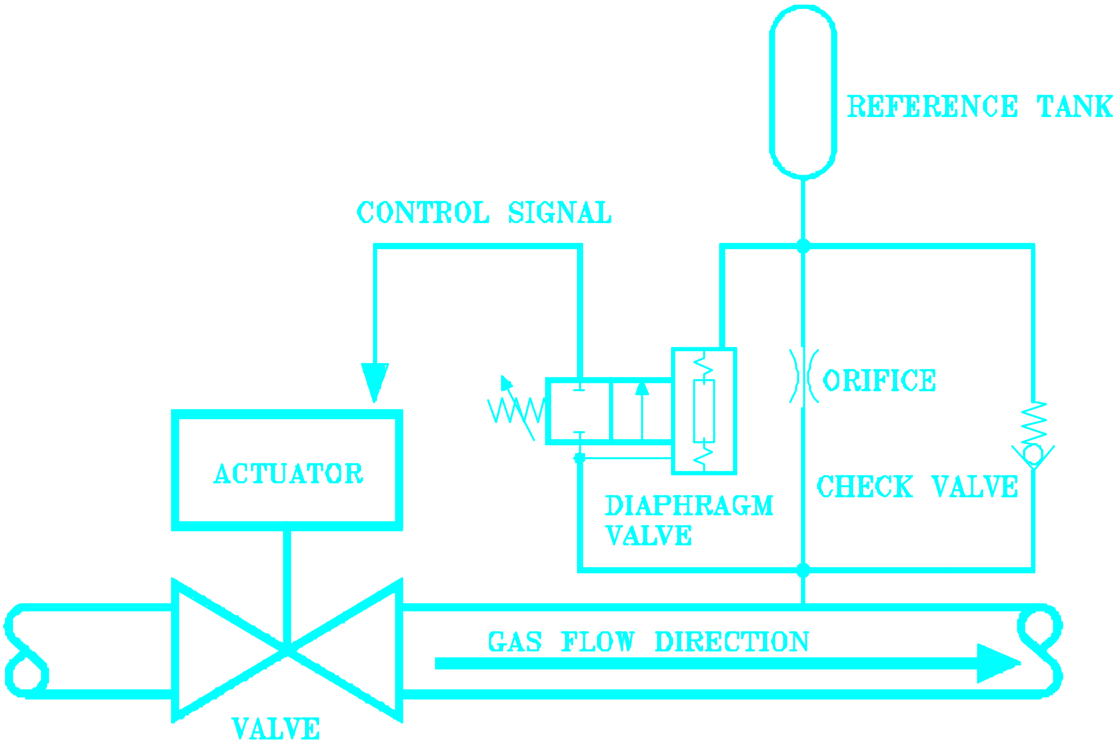
(see figure 1)

A break in the gasline causes an increase of the gas speed and consequently an increase of the pressure drop across the valve, but it is not possible to use it as the signal for the central device operation as, being the valve fully open, the pressure drop is very low.

If a reference tank is connected to the gasline through a calibrated orifice with check valve, when the pressure in the gasline increases, through the check valve the pressure into the tank equalizes immediately the line pressure. On the contrary, when the line pressure decreases, the pressure in the reference tank remains higher than the pressure into the gasline.

The higher is the pressure drop rate in the pipeline, the smaller is the diameter of the orifice, the larger is the volume of the reference tank, the higher is the pressure difference between the reference tank and the pipeline.

This differential pressure is measured by a diaphragm device which, when the differential pressure exceeds the set point, controls the valve closing operation and prevents the valve operation in opening.



PNEUMATIC CONNECTION

Rev.	Date	By	Approved	Description

AutoCad 10.0	Path DECRE C:\LN_BRK BIFFI	WORKING PRINCIPLE OF THE "LINE BREAK" DEVICE -OPERATING DIAGRAM-	Drawing Number FIGURE 1	
			File LB_FIG	Date 12/10/93
			By	Approved

3. Description of the operation of the "LINE BREAK" device

(see the operating diagram SGAMF001)

The "LINE BREAK" device is connected to the gasline downstream to the valve, referring to the gas flow direction, in order to avoid the undesired valve closing when the valve is actuated in opening under differential pressure (we assume in fact that the upstream pressure is always higher or equal to the downstream pressure).

The connection to the gasline can be isolated by the stop valve (601).

The gas used for the device is filtered in the filter (608).

The gasline is connected to the reference tank (31) through the check valve with orifice (625).

When the gasline pressure raises, the check valve opens and the reference tank pressure equalizes immediately the gasline pressure. On the contrary, when the gasline pressure drops, the check valve remains closed and the connection between the gasline and the reference tank is made through the orifice only: in this way the pressure in the reference tank remains higher than the pressure in the gasline.

The gasline and the reference tank are connected to the two chambers of the diaphragm valve (645) and the differential pressure acts on its diaphragm.

The higher is the pressure drop rate, the higher is the differential pressure.

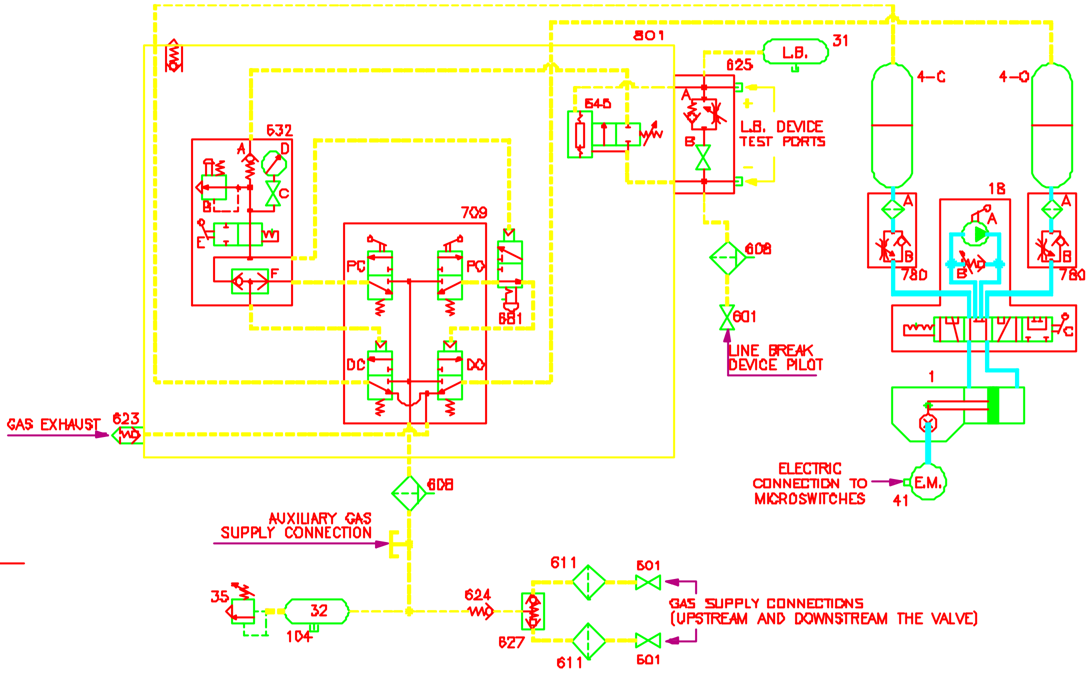
When the differential pressure exceeds the set value of the valve (645) this trips and a pressure signal comes out. The differential pressure value of valve (645) set point is adjustable by the setting of its return spring.

The pressure signal coming from the diaphragm valve controls the actuator operation in closing and prevents the opening operation. The pneumatic signal pilots the valve (681) which stops the connection coming from the valve (709 PO) and connects to the atmosphere the pilot of the "to open" valve (709DO). The pneumatic signal, coming out from the valve (645), pressurizes also, through the valve (632), the pilot of the "to close " valve (709DC).

After the emergency closing operation, controlled by the "LINE BREAK" device, to control the opening operation it is necessary to manually reset the valve (681).

The stop valve (632E) allows to prevent the closing operation controlled by the "LINE BREAK" device: this is necessary when the setting or the working test of the device are performed during the normal operation of the pipeline, and then it is not permitted to close the pipeline valve and consequently to stop the gas flow.

The vent valve (632B) is a safety device which exhausts to the atmosphere the contingent gas leakages of the valve (645) and does not allow that the valve (709DC) is wrongly actuated and consequently an unwanted actuator operation in closing is controlled.



LOCAL CONTROL
PRESS LEVER ON VALVE 709-PO TO OPEN OR 709-PC TO CLOSE WITH GAS SUPPLY

LINE BREAK DEVICE OPERATION
A RATE OF PRESSURE DROP IN THE GAS PIPELINE CAUSES A DIFFERENTIAL PRESSURE ACROSS THE DIAPHRAGM OF VALVE 645. WHEN THE DIFFERENTIAL PRESSURE IS HIGHER THAN THE PRESET VALUE, THE DIAPHRAGM VALVE 645 TRIPS AND PILOTS THE VALVE 681 TO INHIBIT OPEN OPERATION AND THE VALVE 709-DC CAUSES THE ACTUATOR TO CLOSE.
AFTER THE LINE BREAK INTERVENTION, THE INHIBITION VALVE 681 MUST BE MANUALLY RESET BEFORE THE ACTUATOR CAN BE REOPENED
THE LINE BREAK PILOT HAS TO BE CONNECTED TO THE PIPELINE (DOWNSTREAM THE VALVE) AND THE PRESSURE INTAKE HAS TO BE SEPARATE FROM THE GAS SUPPLY PRESSURE INTAKE

MANUAL OPERATION
SELECT BY THE VALVE 18-C THE OPENING OR CLOSING OPERATION AND ACTUATE THE HAND PUMP 18-A
NOTE: THE DIRECTIONAL CONTROL VALVE 18-C MUST BE IN "AUTOMATIC" POSITION TO ALLOW THE OPERATION WITH GAS SUPPLY

NOTE.
THE DIAGRAM IS DRAWN WITH CONTROL VALVES NOT ACTUATED

1 DOUBLE ACTING GAS OVER OIL ACTUATOR
4 GAS-HYDRAULIC TANK
18 HYDRAULIC MANUAL OVERRIDE
A - HANDPUMP
B - ADJUSTABLE RELIEF VALVE
C - HAND OPERATED DIRECTIONAL CONTROL VALVE
31 REFERENCE TANK FOR LINE BREAK DEVICE
32 AIR STORAGE TANK (OPTIONAL)
35 RELIEF VALVE (OPTIONAL)
41 ELECTRIC MICROSWITCHES
104 MANUAL DRAIN VALVE (OPTIONAL)
601 STOP VALVE
608 GAS FILTER/CONDENSATE SEPARATOR
611 MECHANICAL FILTER
623 DUST EXCLUDER WITH CHECK VALVE
624 CHECK VALVE (OPTIONAL)
625 CHECK VALVE WITH ORIFICE FOR LINE BREAK DEVICE
A - CHECK VALVE WITH ORIFICE
B - STOP VALVE
627 HIGHER PRESSURE SHUTTLE VALVE (DOUBLE CHECK VALVE)
632 SHUTTLE VALVE DEVICE
A - CHECK VALVE
B - LOW PRESSURE VENT VALVE
C - STOP VALVE FOR PRESSURE GAUGE
D - PRESSURE GAUGE
E - 2/2 HAND OPERATED VALVE
F - HIGHER PRESSURE SHUTTLE VALVE
645 2/2 N.C. DIAPHRAGM PILOT VALVE (ADJUSTABLE)
681 3/2 N.O. PNEUMATIC PILOT/HAND RETURN VALVE
709 DOUBLE 3/2 N.C. PNEUM.PILOT & HAND OPERATED/SPRING VALVE
PC - 3/2 N.C. HAND OPER./SPRING PILOT VALVE (TO CLOSE)
PO - 3/2 N.C. HAND OPER./SPRING PILOT VALVE (TO OPEN)
DC - 3/2 N.C. PNEUM. PILOT/SPRING RET. VALVE (TO CLOSE)
DO - 3/2 N.C. PNEUM. PILOT/SPRING RET. VALVE (TO OPEN)
780 HYDRAULIC FLOW CONTROL VALVE WITH FILTER
A - FILTER
B - ADJUSTABLE HYDRAULIC FLOW CONTROL VALVE
801 CONTROL VALVES ENCLOSURE WITH VENT VALVE

PNEUMATIC CONNECTION
HYDRAULIC CONNECTION
ELECTRIC CONNECTION

Rev.	Date	By	Approved	Description

Path T:\SCH
BIFFI

GPO GASHYDRAULIC ACTUATOR
LOCAL CONTROL
"LINE BREAK" DEVICE
-OPERATING DIAGRAM-

Drawing Number
SGAMF001

File	Date
SGAMF001	22/06/93
By	Approved

4. Curves to be considered for the "LINE BREAK" device operation

When the pressure into the gasline drops, also the pressure into the reference tank decreases, but with a certain delay, as the connection is made through the calibrated orifice.

The difference between the two pressures increases with the time up to reach a maximum value (dP MAX) and than decreases.

The value of the differential pressure is a function of the gasline pressure drop rate, of the orifice diameter and of the gasline pressure value.

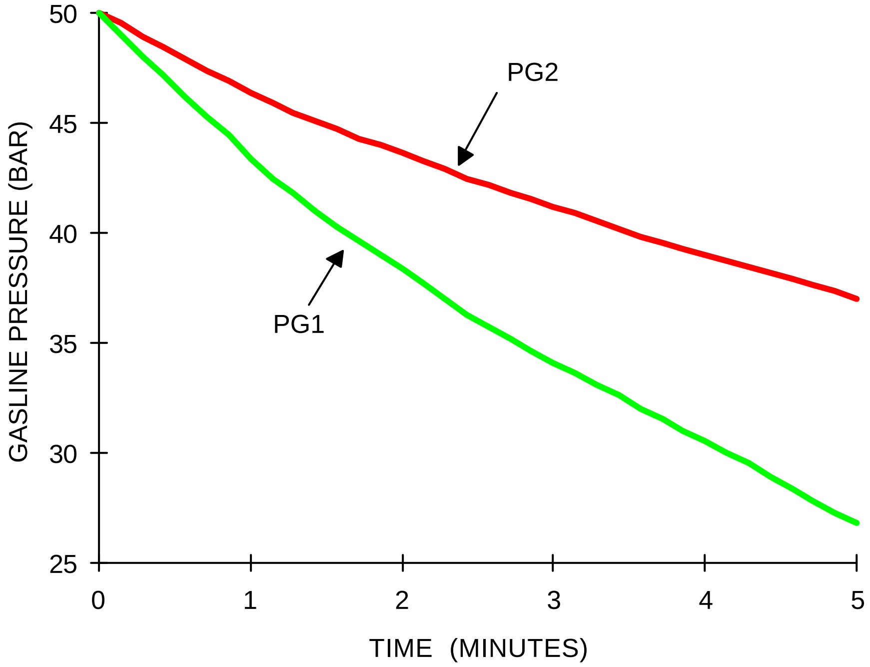
4a. Change of differential pressure with time for two different pipeline pressure drop rates, by same orifice diameter and same pipeline initial pressure

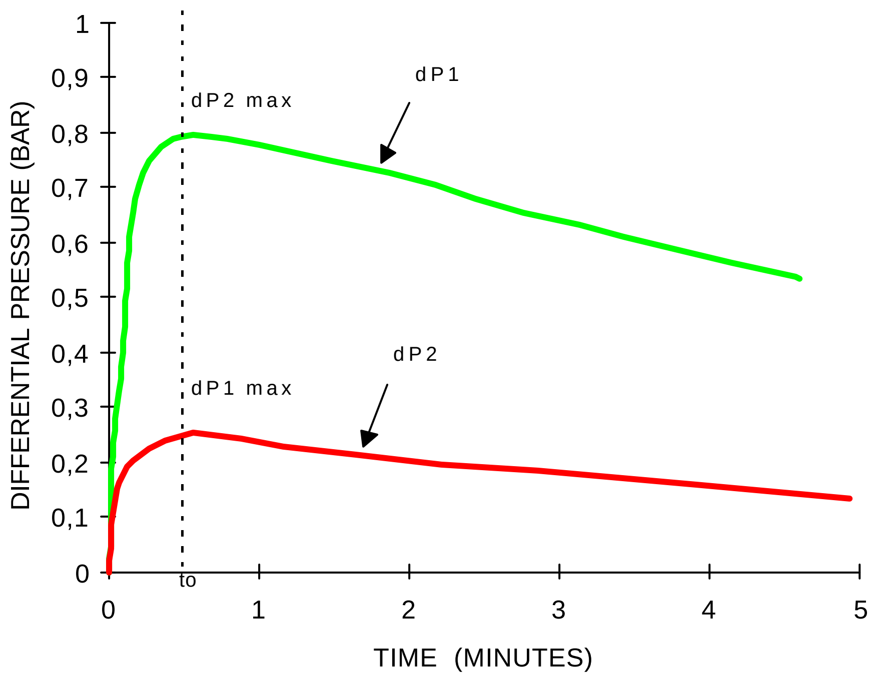
(see figure 2)

The curves of figure 2 show that the differential pressure between the referencetank and the gasline is higher if the pressure drop rate is higher.

The curves show also that, by same orifice diameter, the time "t0" required to reach the dP max value is the same for all the pressure drop rates and it is depending only on the orifice diameter.

Figure 2





CURVES OF PRESSURE DROPS AND OF DIFFERENTIAL PRESSURES
WITH DIFFERENT PRESSURE DROP RATES
BY SAME ORIFICE DIAMETER
AND SAME INITIAL GASLINE PRESSURE

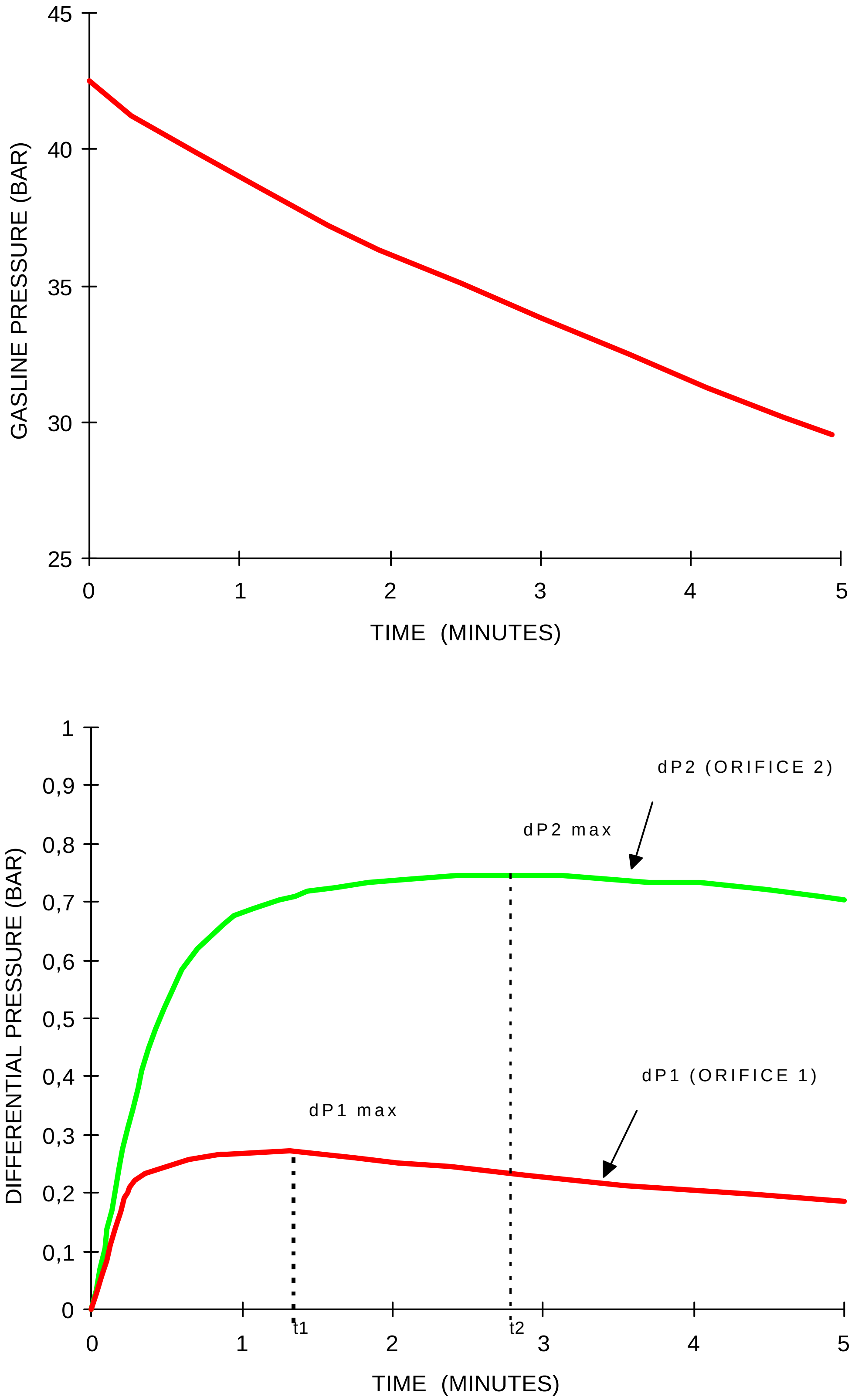
4b. Change of differential pressure with time for two different orifice diameters, by same gasline pressure drop rate and same initial pressure

(see figure 3)

The curves of figure 3 show that by same pressure drop rate, the pressure difference between the reference tank and the gasline is higher if the orifice diameter is smaller: the values of differential pressures dP2 are higher than dP1, being the diameter of orifice 2 smaller than the diameter of orifice 1.

The curves show also that the time required to reach the value dPmax of the differential pressure is longer if the orifice diameter is smaller.

Figure 3



The orifice diameter 2 is smaller than the orifice diameter 1

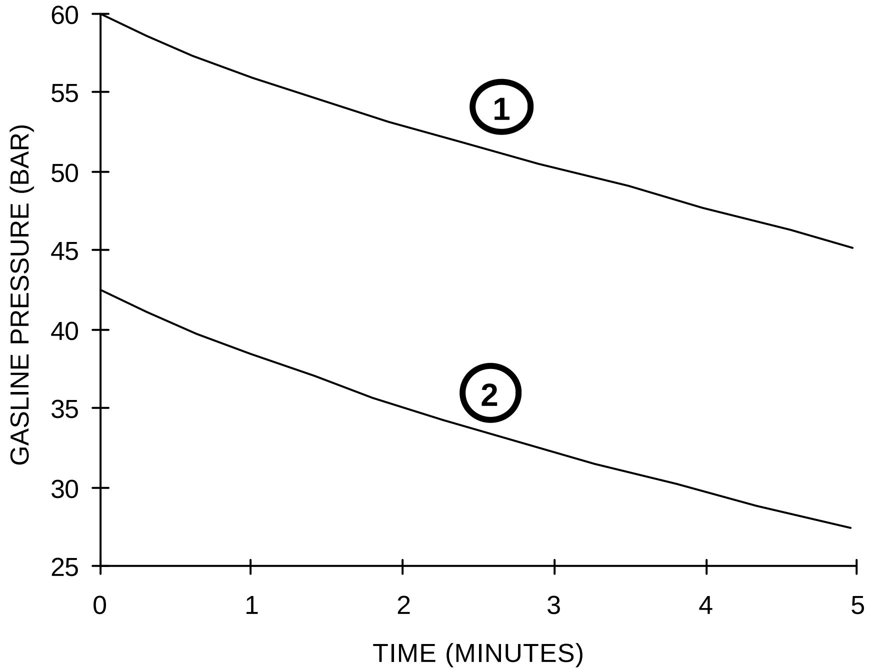
4c. Change of differential pressure with time, for two different initial gasline pressures, by same pressure drop rate and same orifice diameter

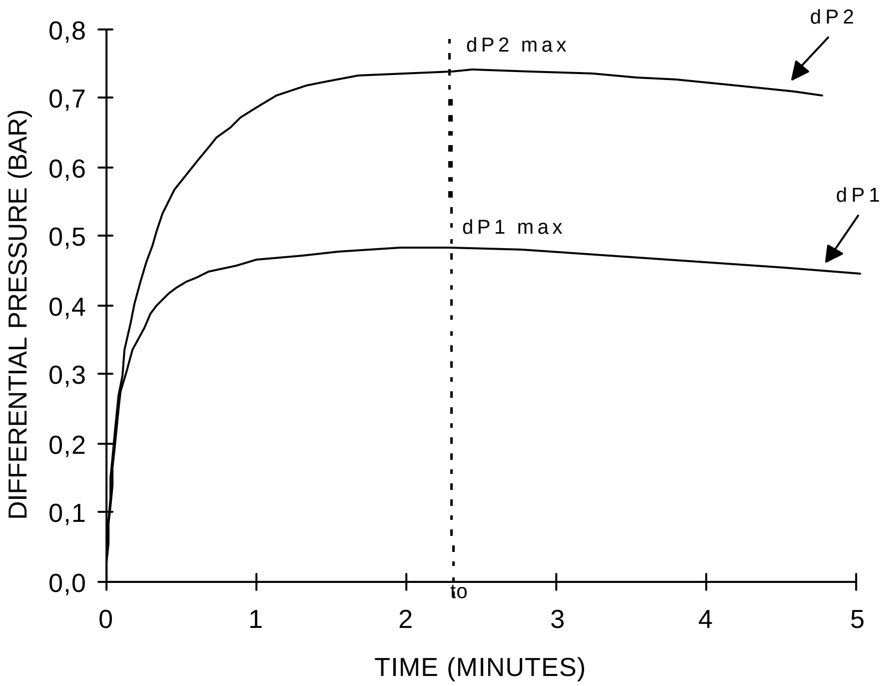
(see figure 4)

The curves of figure 4 show that by same pressure drop rate, the pressure difference between the reference tank and the gasline is higher if the initial pressure is lower: the values of the pressure difference dP2 are higher than dP1, being the initial pressure of the curve 1 higher than the initial pressure of the curve 2.

The curves show also that the time required to reach the maximum values "dP1 max" and "dP2 max"of the differential pressures are the same and are depending only on the orifice diameter.

Figure 4





CURVES OF PRESSURE DROPS BY SAME PRESSURE
DROP RATE BUT WITH DIFFERENT GASLINE INITIAL PRESSURES
AND OF DIFFERENTIAL PRESSURES
BY SAME ORIFICE DIAMETER

4d. Maximum differential pressure values generated by different pressure drop rates, by different gasline initial pressures and different orifice diameters

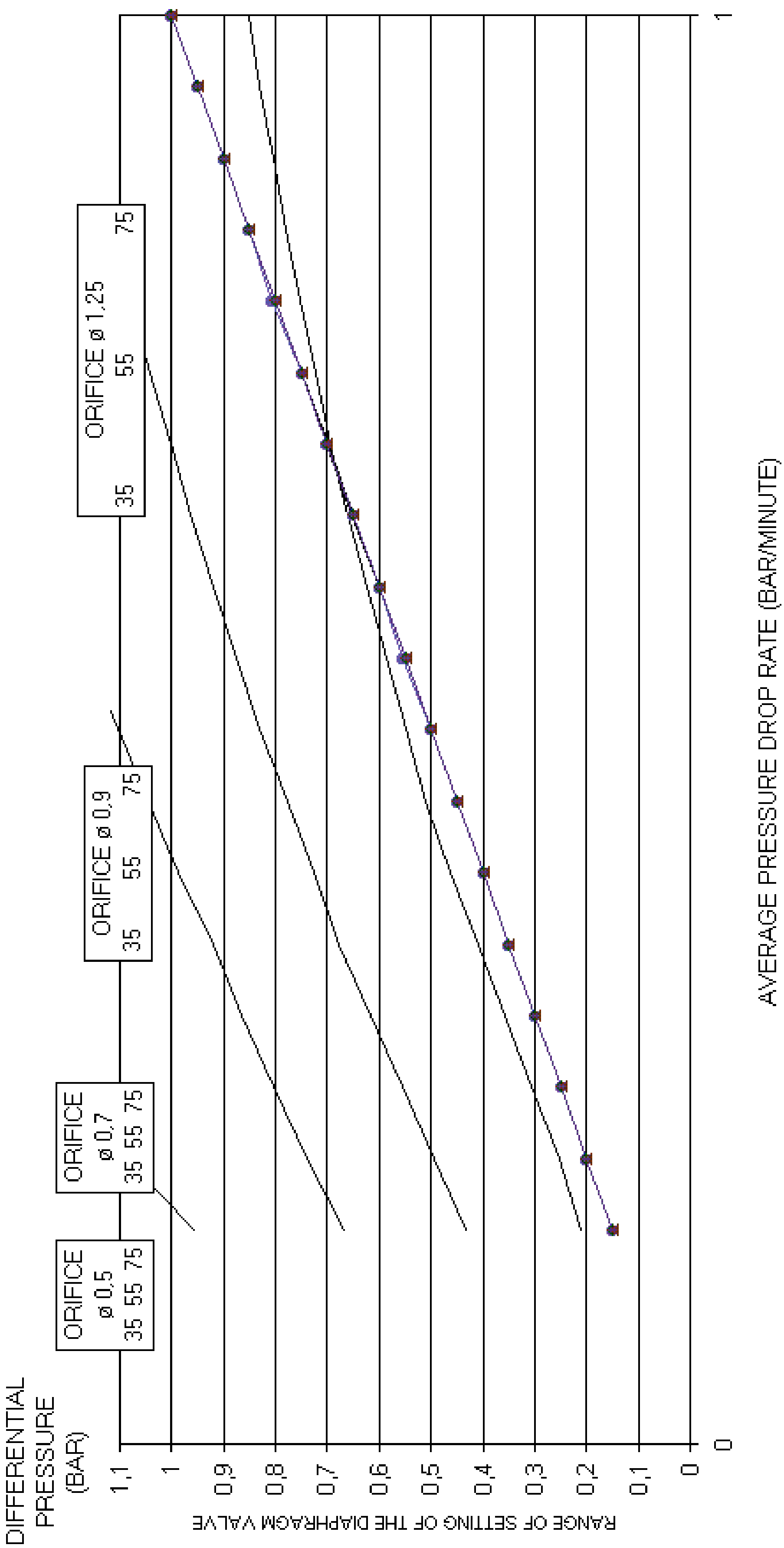
(see figure 5)

The curves of figure 5 give the values of the maximum differential pressure values between the reference tank and the gasline, as function of the pressure drop rate with three different values of initial gasline pressure (35, 55, 75 bar) which are in the range of the normal working pressure of the gaslines.

The curves are drawn for 4 different orifice diameters: 0.5, 0.7, 0.9, 1.25 mm.

The pressure drop rates are calculated as average value during one minute time.

The curves allow to identify the orifice diameter, which has to be used to assure the setting of the "LINE BREAK" device in the actual working conditions of the gasline (pressure, pressure drop rate in case of line breaking).


DIFFERENTIAL PRESSURE (BAR)
1,1
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
ORIFICE ø 0,5 35 55 75
ORIFICE ø 0,7 35 55 75
ORIFICE ø 0,9 35 55 75
ORIFICE ø 1,25 35 55 75
0
1
AVERAGE PRESSURE DROP RATE (BAR/MINUTE)
RANGE OF SETTING OF THE DIAPHRAGM VALVE

5. Setting of the "LINE BREAK" device

(see figures 5 and 6)

To set the "LINE BREAK" device it is necessary to know the working conditions of the gasline:

- range of the gas pressure;
- value of the minimum pressure drop rate, measured in the portion of gasline where the valve is installed, in case of gasline breaking for minimum, normal and maximum working pressures of the pipeline;
- value of the maximum pressure drop rate, measured in the portion of gasline where the valve is installed, during the normal operation , for minimum, normal and maximum working pressures of the pipeline

The device setting must be carried out, so as to avoid the intervention of the "LINE BREAK" device for all the pressure drop rates which can occur during the normal pipeline operation but, on the contrary, to assure its intervention for all the pressure drop rates caused by the gasline breaking.

It is necessary that the pressure drop rate, in the normal working conditions is always lower than the pressure drop rate caused by the line breaking, at the same working pressure.

For the device setting, we must identify a value of pressure drop rate which must cause the device intervention: such value must be higher than all the pressure drop rates which may occur during the normal working conditions, but lower than all the pressure drop rates caused by the line breaking.When the pressure drop rate and the corresponding working pressure have been defined, we can identify the orifice diameter by means of the curves drawn in figure 5: on the abscissas axis (BAR/MIN) we fix the point corresponding to the value of the pressure drop rate selected for the setting. We draw a vertical line up to the intersection with the curve of the maximum differential pressure values related to the selected working pressure.From the intersection point we draw an horizontal line, which crosses the ordinates axis in the point of the maximum differential pressure value which can be used for the setting of diaphragm valve. The value of the differential pressure must be in the range from 0.2 to 1 bar.

For the diaphragm valve setting it is recommended to select a differential pressure value not higher than 90% of the value defined by the above described procedure, to be sure of the device intervention.

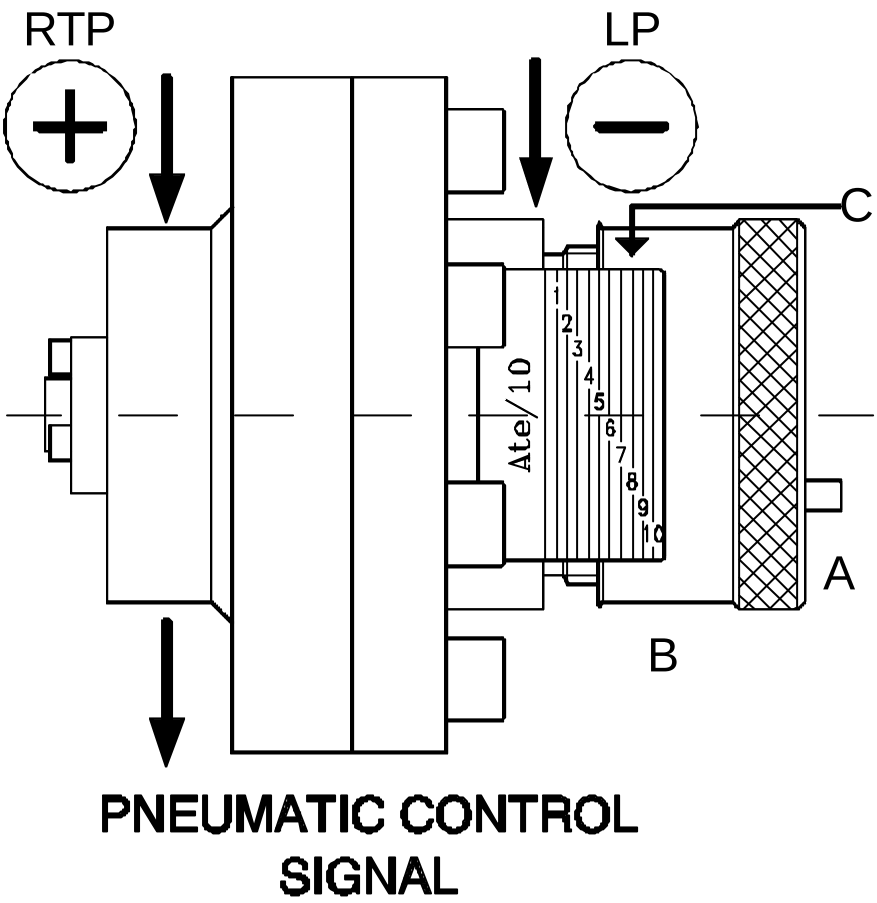
The time required for the device intervention is depending on the diameter of the used orifice.

For the device setting we must install the orifice with the determined hole diameter and we must adjust the diaphragm valve to the selected differential pressure.

For the adjustment of the diaphragm valve (see figure 6) we must unloose the locking screw "A", which prevents the rotation of the setting ring nut.

Turn the ring nut "B" until his edge reaches the position correspondent to the selected differential pressure value shown by the scale of the nameplate "C".

Figure 6



SETTING OF THE DIAPHRAGM VALVE

5a. Example of the device setting

(see figure 7)

Let's suppose that the gas pressure into the pipeline is 55 bar, that the maximum pressure drop rate during the normal operation is 0.5 bar/min and that the minimum pressure drop rate caused by a line breaking is 1.5 bar/min.

We select to set the device so to cause its operation in case of a pressure drop rate of 1 bar/minute.

By using the curves of figure 5, which are also plotted in figure 7, we can check that the orifice to be used is the 0.5 mm. diameter one, in order to obtain a differential pressure in the range between 0.2 and 1 bar.

On the abscissas axis (BAR/MIN) we fix the point corresponding the pressure drop rate value = 1 bar/min.

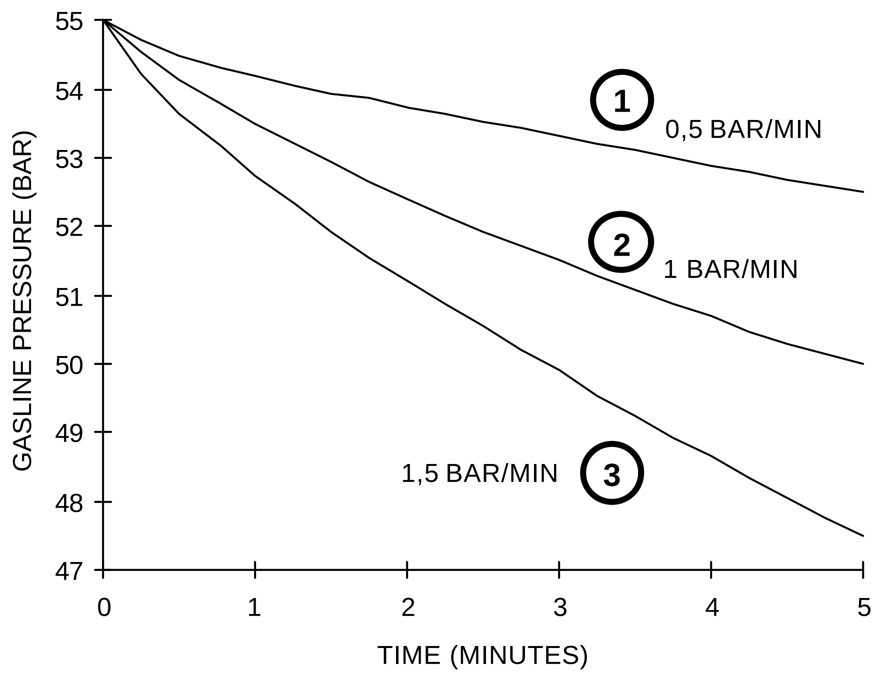
We draw a vertical line up to the intersection with the curve of the maximum differential pressure values related to the working pressure 55 bar.

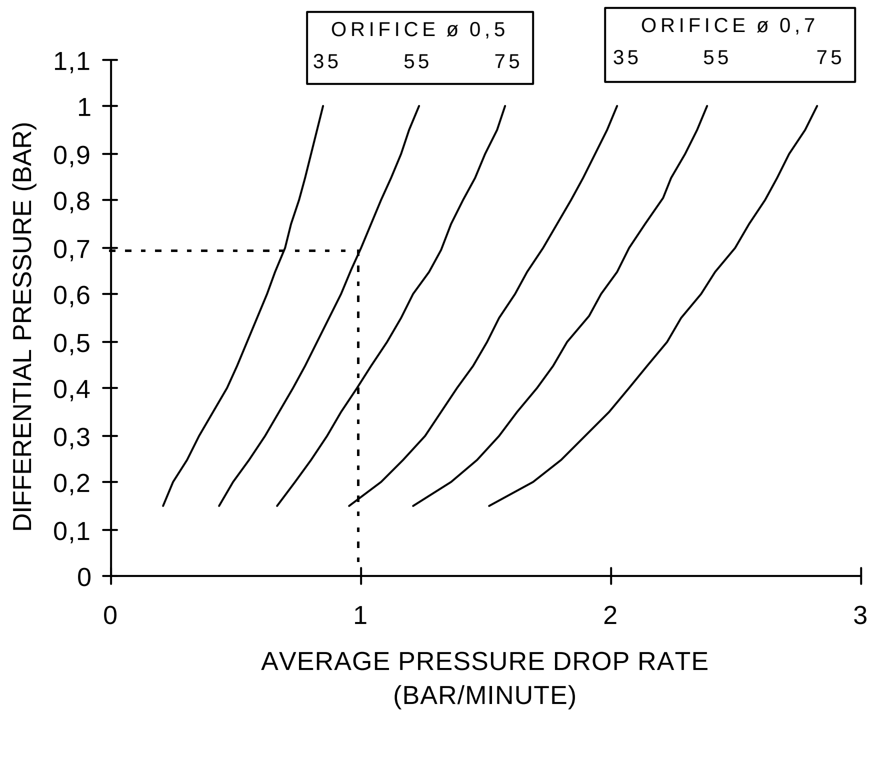
From the intersection point we draw an horizontal line, which crosses the ordinates axis in the point of differential pressure 0.7 bar.

In order to be sure of the device intervenction, we decide to set the diaphragm valve at the differential pressure 0.6 bar.

For the device setting it is necessary to install the orifice with hole diameter 0.5 mm. and to adjust the diaphragm valve at differential pressure value 0.6 bar.

Figure 7


55
54
53
52
51
50
49
48
47
0
1
2
3
4
5
GASLINE PRESSURE (BAR)
TIME (MINUTES)
1
0,5 BAR/MIN
2
1 BAR/MIN
1,5 BAR/MIN
3


ORIFICE ø 0,5
35 55 75
ORIFICE ø 0,7
35 55 75
1,1
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
0
1
2
3
DIFFERENTIAL PRESSURE (BAR)
AVERAGE PRESSURE DROP RATE
(BAR/MINUTE)

6. Check of the setting and working of "LINE BREAK" device by portable control unit

The check of device working and setting (if the working conditions are specified by the customer) are carried out at the Biffi test department and the test certificate is supplied with the "LINE BREAK" device.

If it is required to check on site the good working of the "LINE BREAK" device, that means to check that the device controls the valve closing operation and inhibits the valve opening when the gas pressure drops with a rate higher than the value fixed for the device setting, a portable control unit, supplied by BIFFI, can be used.

The above mentioned control unit can also be used to check the value of the differential pressure set on the diaphragm valve of the "LINE BREAK" device.

The procedures for the above mentioned checks are described in the documentation "DT 5006 E" related to the "ELECTRONIC PORTABLE UNIT WITH DIGITAL PRESSURE GAUGE INSTRUMENT".