GAS DIVIDER WITH TWO DILUTING RANGES - Mod. BETACAP30X100

INTRODUCTION

BetaCAP30X100 is the clever combination of two diluters :

- the well known 30 steps gas divider built in a 19" rack mod. BetaCAP30RK
- The more recent fixed divider 1:100 compact module mod. BetaCAP1A100.

Evaluating the combination of those devices we did realize that a new product did born with a new functions set.

From the applications point of view, the diluter is suitable both for emissions monitoring and for ambient air quality.

From the operational point of view, this device may be operated in two ways :

a) traditional way where the user selects the dilution ratio (0:30….30:30 and 1:3000...30:3000) and may read the concentration of the diluted gas ;
b) a new way, never seen before in a capillary type gas divider, where the user selects the diluted gas concentration in the range 0,02% to 98,3% of the span gas, without being conditioned by the discrete steps typical of capillaries.

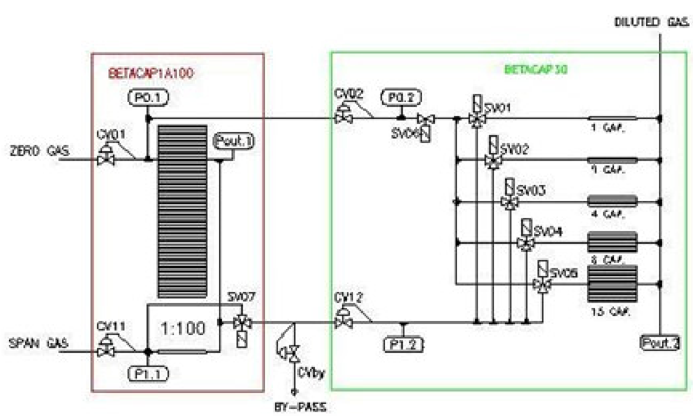
This gas divider offers the flexibility that we may find in MFCs type gas diluters, but joined to the accuracy, stability and availability typical of capillaries

MAIN FEATURES :

- **30 + 30 dilution ratios available in two ranges (with pre-divider on or bypassed)**
- **PID pressures regulation in pre-divider, bypass and final divider (repeatability ± 1 mBar)**
- **Internal circuits made by materials (glass, PVDF, PEEK, PTFE, AISI316L, Viton) corrosion resistant**
- **Compact construction with manifolds to minimize fittings and tubes number (reduction of leakages)**
- **Automatic compensation of certified errors for both dilution stages**
- **Compensation of different gas viscosities (viscosity is the sole gas property that may affect dilution with capillaries)**
- **Analog signals isolation and acquisition for 3 measuring signals from the gas analyzer under test**
- **Available options : Software for automatic testing, Multiple test gas switching unit.**

CONSTRUCTION AND OPERATING PRINCIPLES

The main diluter is well described in the data sheet BetaCAP30, than this document will focus on pre-divider and interface between the two modules.
The pre-divider inlets (gas to be diluted and diluting gas) are protected by two fine filters to prevent dusty fittings from releasing dust in the circuits.
All the gas contacted parts are corrosion proof using fluorinated plastic compounds, glass, stainless steel 314L. It's also available an "all steel" version to reduce the delays due to plastic saturation and permeability (with HF, NH_3, O_2 very low ranges).
All the internal parts of the pre-divider module BetaCAP1A100 are built to accept input pressures of max 5 Bar, and the final divider BetaCAP30 to accept pressures of max 2,5 Bar. The pressure applied to the pre-divider is higher than the pressure applied to the 30 steps divider.



A detail that is immediately evident is the apparent incompatibility between the flow variable (with dynamic 0 to 30) at the entrance of the final diluter, compared to flow produced by the prediluter, which instead is basically fixed.
The back pressure regulating valve VRby leaves vent (bypass) a pre-diluted gas flow which compensates for variations in the flow of gas from the entrance of the final diluter : In this way, it maintains a constant flow of pre-diluted gas and consequently the pressures at the ends of pre-diluter.

The differential pressures (input-output) of the two ways (diluent gas and gas to be diluted) in both modules are accurately regulated (± 1 mBar) to control the dilution process : in fact, a change of the applied pressure corresponds to a proportional variation of the induced flow in the capillary and than a dilution change.

As we shall see, this ratio $P_{(TG1)} / P_{(TG0)}$ is of fundamental importance in both the pre-diluter diluter and the final diluter.
This is the function that faithfully represents the behavior of a diluter with equal capillaries:

$$K_{DIL} = \frac{N}{N + (TOT - N) \times P_{TG0}/P_{TG1} \times \eta_{TG1}/\eta_{TG0}}$$

- K_{DIL} is the dilution ratio
- N is the number of capillaries involved by the gas to be diluted
- TOT is the total number of capillaries
- η is the viscosity of the gas or the gas mixture

The index $_{TG0}$ refers to the diluent gas, and $_{TG1}$ refers to the gas to be diluted.
For a diluter as BetaCAP30, N is an integer between 0 and 30, while TOT = 30
For a diluter as BetaCAP1A100 (our pre-diluter), N = 1 and TOT = 100. In fact in the pre-diluter there are 100 capillaries, one of which is crossed by the span gas and 99 by the diluting gas.
The total dilution ratio (the series between the pre-diluter and the diluter final) corresponds to the product between the dilution ratios of the two elements.

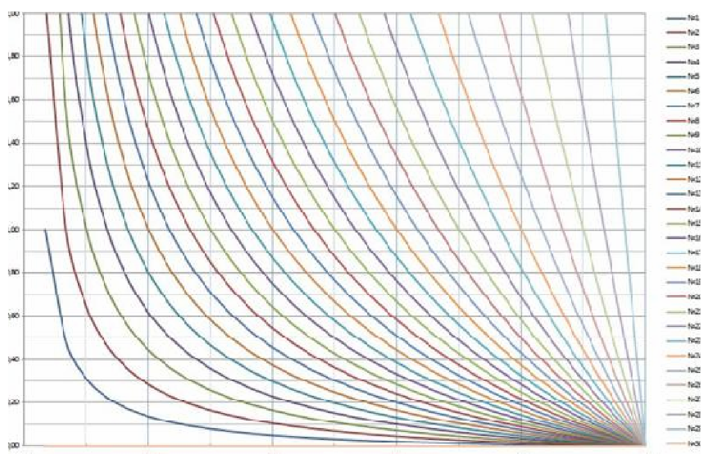
In both modules, the pressures regulation function accepts two set points : $P_{(TG1)}$ and the ratio $P_{(TG0)} / P_{(TG1)}$. An additional set point is available to set the bypass control (interfacing the two modules).

Viscosity compensation : is a practice we use since longtime. In the earlier versions of BetaCAP30 it was manual (the user sets the pressures ratio setpoint at the same value of the viscosities ratio) now is automatic.

- when the pre-diluter is used, viscosity compensation is applied to the pre-diluter only (the final diluter will handle two gases very similar because one is pure diluting gas and the other is diluted 100 times with diluting gas).
- when the pre-diluter is bypassed, viscosity compensation is applied to the final diluter.

When the active gases concentrations in the span gas are lower than few percent, the difference of viscosities may be neglected ($\eta_{TG1}/\eta_{TG0} \sim 1$)

Continuous dilution range : is a new practice that uses the above formula to move the dilution ratio by manipulating the ratio $P_{(TG0)} / P_{(TG1)}$. It's evident that increasing this ratio value, the flow of the zero gas do increase and the dilution ratio too, and vice versa decreasing the ratio. In the side chart, we may see the 30 lines, one for each N (number of capillaries crossed by the span gas) in the space x= dilution ratio and y= ratio $P_{(TG0)} / P_{(TG1)}$. Using this practice, the entire area of dilution factors may be covered just playing with the pressures ratio. Knowing the span gas concentration (and his viscosity) and the wanted concentration, the gas divider may find the best "N" and the correct pressures ratio value to get the target.



OPERATION OF THE GAS DIVIDER

The operator is faced with a simple interface: alphanumeric display (4 x 40 characters), and 5 function keys, with whom he may select the menu and set a few parameters needed to operate.
The menus hierarchy originates from 4 independent lines :

- Initial configuration : concerns the construction details (installed options, basical adjustments, PID parameters and correction parameters that, on the base of the metrological certificate, correct the measured errors.
- Calibrations: contains the sub-menu for the calibration of the analog signals acquisition and for the two groups of three pressure sensors. The pressures calibration is "static" (without gas flow, the pressure is uniformly distributed inside the unit) and don't requires traceable references (the sole purpose is of aligning the sensitivities of all the measurements after having corrected the offset (using environmental pressure).
- Parameters accessed by the user : like the concentration of span gas, his viscosity, the set points of the pressure controls (both for pre-diluter and final diluter)
- Operation modes : with three possibilities : "dilution factor selection" mode , "diluted concentration selection" mode, "remote" mode

The first three menu groups are password protected
We see more in detail just the operation mode menus :

- Mode "dilution ratio selection" : is classical for a capillaries type gas divider. The user must set the integer value of N (0<N<30) and the denominator of the ratio (30 when the pre-divider must be bypassed or 3000 when it's required). The display indicates all the pressures of the final diluter and the expected diluted concentration
- Mode "diluted concentration selection" : it's an unconventional way, that get advantage of the above theory to drive the gas divider obtaining the target result. In the indicated order, it manage automatically the following choices :
  1. including or bypassing the pre-diluter module
  2. Defining the number N of capillaries to be crossed by span gas
  3. Calculating and applying the set points of pressures ratio for pre-divider and final divider

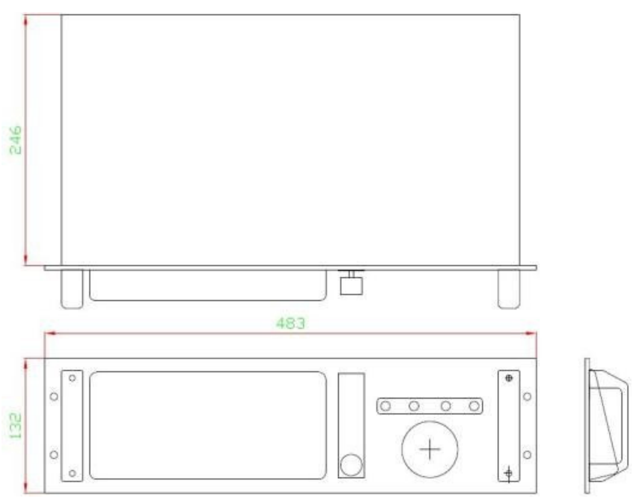
The function that is applied, do also uses the viscositiy values, to find the best N value to minimize the difference between P(TG1) and P(TG0) and corrects according to the certified errors

- “Remote” mode : through the serial port RS485 with AK protocol, both pre-diluter and final diluter receive commands from a PC : the command types do include all the functions that may be called locally . The optional software Info-CAP30 is designed to handle programmed sequences : receiving the measuring values acquired by the diluter it may show the trends of real and theoretical concentrations and write reports complying with the norm EN14181.

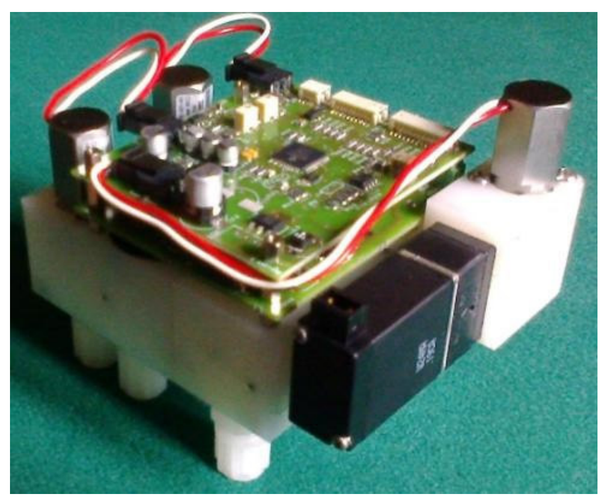
TECHNICAL SPECIFICATIONS

Dilution ratios (discrete mode)	:	31 discrete values regularly spaced between 0:30 and 30:30 30 discrete values regularly spaced between 1:3000 and 1:100
Dilution ratios (continuous mode)	:	all the diluted values between 0,022% and 98,33% of the span gas
Dilution accuracy (natural)	:	better than 0.5% of reading + 0,0003% of the input concentration
(after calibration)	:	better than 0,2% of reading + 0,0001% of the input concentration
Dilution repeatability	:	< ± 0.2 % of reading
Input pressure	:	up to 5 Bar at inlet fittings
Flow of diluted gas	:	depends on the regulated pressure and capillaries size - small capillaries size from 0,2 to 2 L/min. - big capillaries size from 0.6 to 6 L/min.
Gas connections inlet	:	Span gas and diluting gas
outlet	:	diluted gas and bypass
Connection types .	:	compression fittings 4 x 6 mm PVDF (AISI316L upon request)
Metrological certificate	:	optional, from an European accredited laboratory
Gas contacted materials	:	AISI 316, Glass, PVDF, PPS, PEEK, Kalrez, Viton, epoxy resin.
Main measurements	:	3 rel. pressures for pre-divider and 3 rel. pressures for final divider
Other measurements	:	barometric pressure and internal temperature
Acquired measurements	:	3 concentration signals from gas analyzers (isolated from diluter)
Serial communication port	:	RS485 (with USB converter) open protocol type AK
Electric power	:	100 ... 240 Vac - 0,8 A max.
Size and weight	:	19” std. h 3UT dept. 250 mm - weight 10 kg

** The uncertainty of the certifying laboratory is not considered.



Size and layout of the 19” Rack



Pre-divider module BetaCAP1A100

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