



A GAS DIVIDERS FAMILY DESIGNED TO SATISFY USERS REQUIREMENTS FOR MANY APPLICATIONS

- **GAS ANALYZERS LINEARITY AND CROSS INTERFERENCE TESTING**
- **CEMS TESTING LINEARITY (EN 14181–40CFR Part 75 App.A Par. 6.1)**
- **AIR QUALITY ANALYZERS NETWORK TESTING WITH HIGH CONCENTRATION TEST GAS BOTTLES**

The most appreciated quality of the BetaCAP gas dividers family is robustness and stability of the high initial accuracy.

The reason for that is mainly :

- using manifold type construction with highly corrosion proof materials
- using glass “equal” selected capillaries
- using electronic pressures control and very linear pressure sensors

The above points, together with original improvements with certified errors correction, viscosity compensation and very flexible operating modes are the distinguishing features of our production.

The initial concept is very easy :

Equal pressures, applied to equal capillaries do induce equal flows. The dilution is then moved from flows ratio to numbers (of capillaries) ratio

Dilution ratio = N / TOT , where N is the number of capillaries crossed by the span gas and TOT is the total capillaries number.



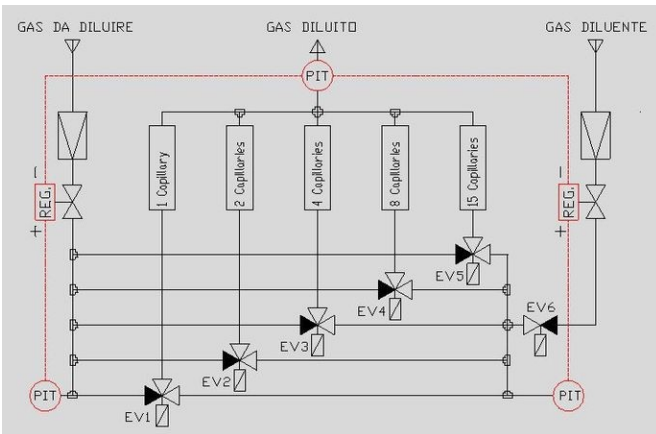
MANIFOLD TYPE CONSTRUCTION :
 Building a device inside and on the surface of a rugged manifold is a way of getting many advantages :

- First of all the robustness of the whole
- Second low leakages. All the connections between the circuit elements are made by communicating holes drilled in the solid. No fittings and tubes.
- Third very low dead volumes and then faster response time.
- Last, the production repeatability

THE PARENT OF THE FAMILY : THE GENERAL PURPOSE DILUTER BETACAP30



With 30 equal capillaries made of glass is designed to satisfy the analyzers testing requirements in the field of CEMS and process. The basic operating mode allows selecting 30 dilution steps spaced 3,33% in the range 0...100%.



Another operating mode allows freely selecting the wanted diluted concentration in the range 1,667%...98,333% (zero and span are also available). This second mode, typical of MFC dividers, uses pressures control with advanced calculations to set the pressures ratio getting the continuous range covering. With both modes, when required it may be activated the viscosity compensation and the certified errors correction functions.

BetaCAP30 is available in a compact case or in a 19" rack, protected when requested by a plastic case with handle. The second version is designed for fixed installations or just to hold internally one or more optional modules.

An analog signal acquisition module for three analyzer measuring signals is available to get advantage from the remote control by PC : knowing the analyzers response, fully automatic testing is realized.

Pressures are measured individually, but controlled in differential way (IN—OUT) on both sides (gas to be diluted and diluting gas) : Then the wanted pressure is applied directly to capillaries and back pressure has no influence on the test.

The user may set different values as pressures regulation set point : this just change the output diluted gas flow, because the pressures ratio is controlled by the electronics. Just the pressures ratio do influence the dilution ratio : this property allows calibrating the pressures meters with a rough and not traceable pressure reference where the reference accuracy is not influencing the calibration of pressures ratio. During the calibration procedure a zero (environmental pressure) and a span (rough pressure source) are applied in sequence to all the internal diluter volume, including the three sensors, which get the same zero offset and the same sensitivity : that's enough for a perfect alignment. The big advantage is that pressure sensors drift may be corrected even daily in few minutes and without special tools.

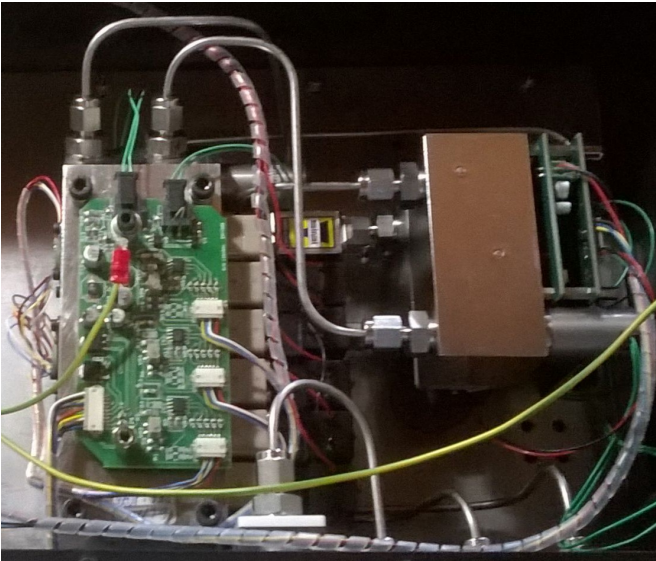


BetaCAP30CP : the compact version

THE FAMILY GROWS : FOR VERY HIGH DILUTIONS BETACAP30X100

It's a lucky combination of a 30 steps diluter (BetaCAP30) with a fixed ratio 100:1 diluter BetaCAP1A100, to provide two diluting ranges (one bypassing pre-diluter and another activating) :

- 31 steps wide 3.33% from 0 to 100% (the same range of BetaCAP30)
- 30 more steps wide 0.0333% from 0.0333% to 1% (this range is perfect for air quality analyzers, using high concentration test gas bottles).



For BetaCAP30X100 too it's available the continuous dilution mode, where the diluted concentration may be set in the range 0.01667% ... 98.33% (it means a minimum dilution up to 6.000 : 1 with capillaries !)

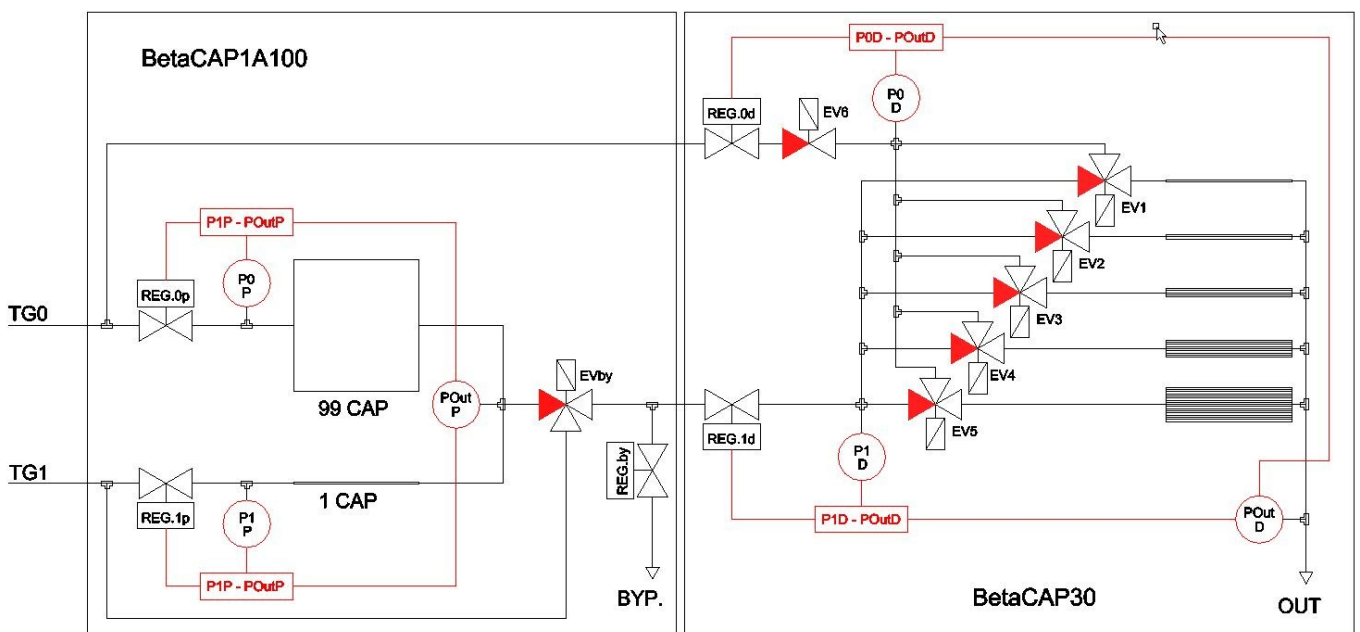
Standard version is made using fluorinated plastics, but an "all steel" version using AISI 316L steel is available for special applications.

Various tricks are used to get compatible the flows coming out from the pre-diluter with the flows required by the diluter : the first basically stable and the second highly variable (from 0 to 100% changing the dilution ratio).

Output diluted flow may be set depending on the analyzer requirements, setting the REG.1d working point. Consequently the REG.1p must be set to supply a little more than the required flow when the diluter works at 30:30 dilution.

When the dilution is reduced, the electronic back pressure regulator REG.by vents automatically the pre-diluted gas excess to maintain constant the output pressure of the pre-diluter.

Using pressures setting or operating menus, all the measured pressures are displayed so that the user have a clear overview of the system : alarms of LL or HH pressures are also indicated. The system self-protects against too high applied pressures up to 8 Bar.



The functional diagram is drawn in "pause" conditions (without powering the solenoid valves)

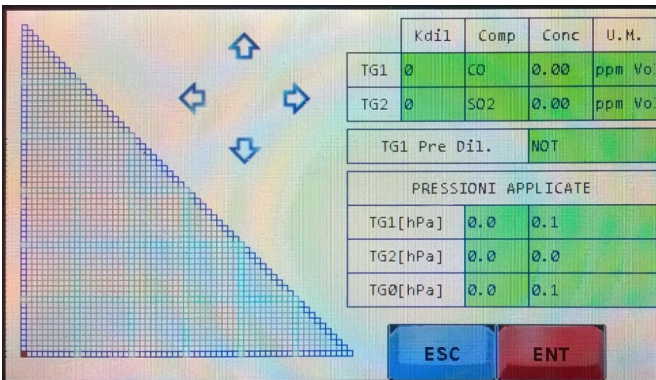
THE LAST BORN : BETACAP60-3G FOR THO INDEPENDENT DILUTIONS

It's a 3 inlets diluter, designed to easily allow cross interference and linearity tests.

Each of the three inlets (measured gas, interfering gas and diluting gas) may be addressed to a number of capillaries between zero and 60.

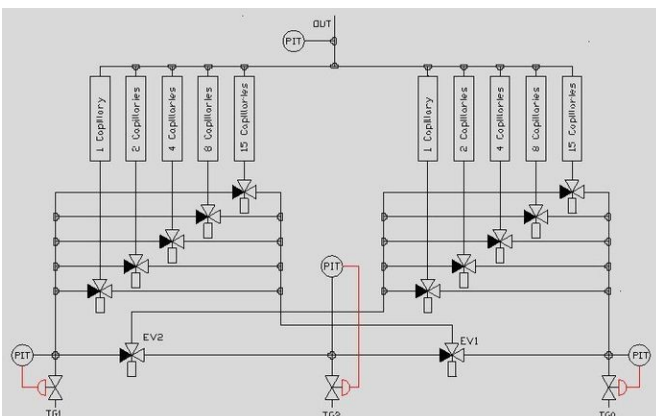
The "step by step" operating menu shows very well the "dilutions space": the horizontal and vertical sides of the triangle are divided in 60 small squares, and each square in the triangle is a possible dilution point both for TG1 and TG2.

Moving on horizontal and vertical sides, dilutions use just two gases (measured and diluting or interfering and diluting). Moving inside the triangle all the combinations are possible, with the obvious limit of the total dilution ($K_{dil.1} + K_{dil.2} \leq 60:60$) which is defined by the triangle hypotenuse : along this side the diluting gas is null.



Another operating menu (typical of the Beta-CAP family) allows the direct setting of both the diluted concentrations in a continuous way.

The bigger memory size included in the new electronics allows for automatic calculation of the mixtures viscosity, so the compensation don't requires any user activity but inputting the test gases composition.



Cap60-3G functional diagram



Analyzing the functional diagram, we did discover how to greatly improve the dilution accuracy : you may note that we have in the device two groups with identical capillaries number for each group size (1, 2, 4, 8, 15 capillaries) and that each group is double size of the previous (with a small exception for the last with 15 capillaries in place of 16). Another important point is that to assure the best dilution accuracy in a diluter it's not important that single flows through capillaries are a well known value, but just the proportions between the flows must comply with the relevant capillaries number.

This fact authorize selecting an internal reference and relating all the measured flows to the reference capillary flow.

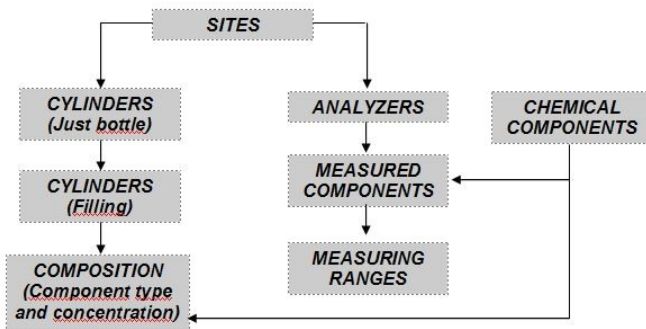
We kept available a calibration procedure, managed by PC, and using an optional multi-range flow meter built into the diluter : the procedure starts comparing the left side single capillary (our internal reference with error = zero by assumption) with the right side single capillary and calculating the relative error. Then compares the flow through two single capillaries (now we may correct this measurements with the calculated errors) with the flow through the left side capillaries couple and with the right side capillaries couple, calculating the relevant relative errors, and so on. Equations do state the equality of the theoretical flows (in case of perfect capillaries equality) and introduce theoretical flows by deducting already known errors and the errors to be calculated to the measured flows. Here is indicated just the idea : a more complete explanation may be found in our web site as PPT presentation or PDF text..

OPTIONS : SOFTWARE PACKAGE FOR AUTOMATIC TEST SEQUENCES

It's a complete package designed to handle automatically linearity tests using each diluter of the BetaCAP family.

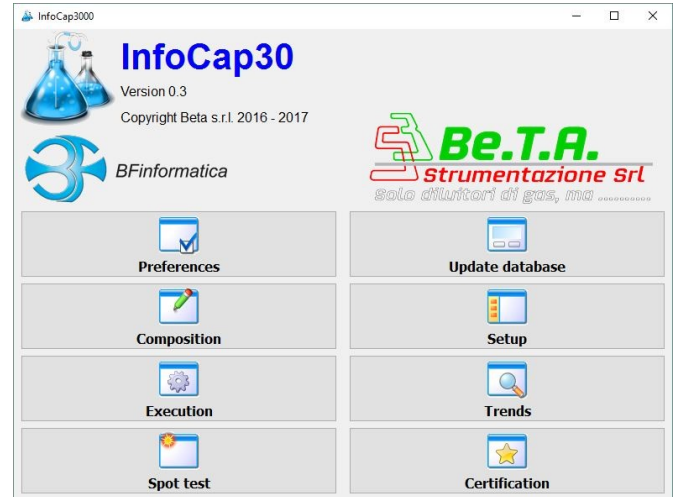
InfoCAP3000 software is organized by cards that may be combined on the screen.

The first operating step is inputting the information related to test gases available and gas analyzers to be tested : this work seems to be wasted, but it will be well recovered during the test composition and the report editing. Basic information are organized as a relational data base, where the head of the relations is the "Site" (it may be the Client or the plant or the store where test gases or analyzers are located).



The composition card allows easily composing the sequence by selecting the wanted instruction (reduced set) from a drop down menu and setting few parameters when required

The Setup card is used to define (recovering from the DB) the analyzer and the gas bottles involved in the test, together with the relevant connection points to the diluter



The Execution card allows launching the test having an overview of all the real time measuring (pressures, concentrations (theoretical and measured) and alarms.

The Trends card displays graphically the trend of measured concentrations vs. expected values.

Spot test card allows managing the test in real time : is something like a remote control of the diluter, but it allows storing the executed sequence for a later automatic run.

Certification card allows recovering the test data, one key editing according to a selected form , which may be customized by the User.

Very interesting the possibility of selecting different user languages or even to easily translating all the texts in a new language.

OPTIONS : MTGS Multiple Test Gases Selection Module



MTGS is an optional module that may be installed with a rack mounted diluter or in a separate box, to select one of 6 bottles with span gas and one of two diluting gas bottles.

This function is driven by the above software to handle test sequences involving more analyzers and more test gas sets.

MTGS also offers analog inputs multiplexing to allow receiving two measuring signals from analyzers for each selected test gas

MTGS is generally used when a gas measuring system is frequently subject to calibration and linearity tests : with MTGS and software the tests may be launched periodically without requiring the User assistance.

"EQUAL" CAPILLARIES ADVANTAGES

GENERAL DISCUSSION :

Diluters are devices producing flow ratios :
 $K_{dil} = \text{flow of span gas} / \text{total output flow}$.
When dilution ratio is very small the difference between the nominator and denominator in the ratio becomes very high.

This may be a problem when those flows must be measured (compared) during production (to select the proper components (i.e. nozzles or capillaries) or to linearize components (i.e. MFCs, which are intrinsically not linear).

The problem is due to the fact that the same flow meter may not be used for measuring both terms of the ratio (limits in the resolution) and the two required meters must have a different range and probably a different traceability chain.

The advantage of measuring a flows ratio (one term may be reference for the second) is lost, because the two measurements are just correlated through the traceability chain. We know that the uncertainty of a very good flow meter is in the range of 0.8..1% of the reading : in the worst case the errors have opposite signs and the combination is additive.

EQUAL CAPILLARIES :

The production process of capillaries don't allows a direct utilization of the produced lot : it must be classified measuring the flow at constant pressure for all the units and dividing the lot into more similar classes.

Finally, from the classes containing a bigger number of capillaries it's possible to extract the "equal capillaries" required to produce one diluter, repeating with higher accuracy the selection process and recording the measured value for each unit.

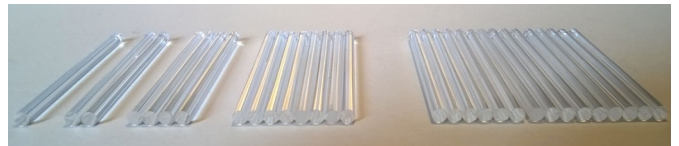
Where is the advantage ?

- we are just interested in comparisons using a single flow meter, than we don't care about the traceability
- we measure all the values in a narrow band of the measuring range, then the linearity of the meter is not affecting the comparative results

- For the same reason we may (setting the applied pressure) set the reading zone in the best resolution area of the meter (90...100% of the range)

The uncertainty of the differential values between selected capillaries is better than 0.2...0.4% rel. : more than 4 times better than the general case. Errors are mainly due to repeatability in flow measuring and in pressure set maintaining.

CAPILLARIES GROUPS COMPOSITION



In BetaCAP family diluters, equal capillaries are grouped in a way of reducing the required solenoid valves : groups are composed using the selected capillaries.

The first group (single capillary) will be loaded with a capillary whose measured flow is near to the mean value of the measured capillaries.

All the other groups are composed with some scarce and some abundant capillaries in a way that differences related to the first (the internal reference) are perfectly compensated.



Be.T.A. Strumentazione S.r.l.

Via 4 Novembre, 8/10 - 28071 Borgolavezzaro (NO) - Italy
Tel.: +39 0321 887712 - Mail : info@beta-strumentazione.it