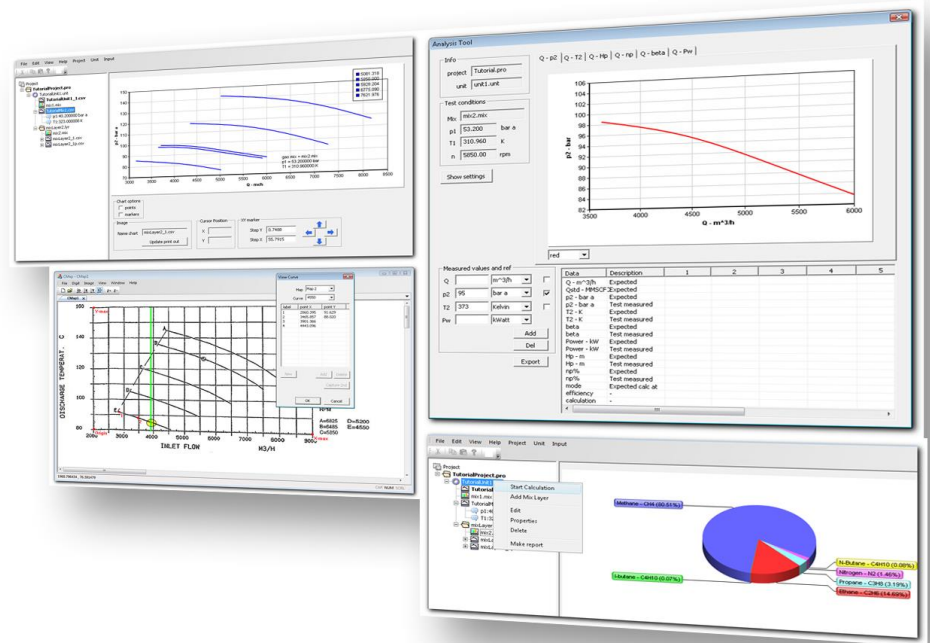




Cmap

Performance Evaluation Software

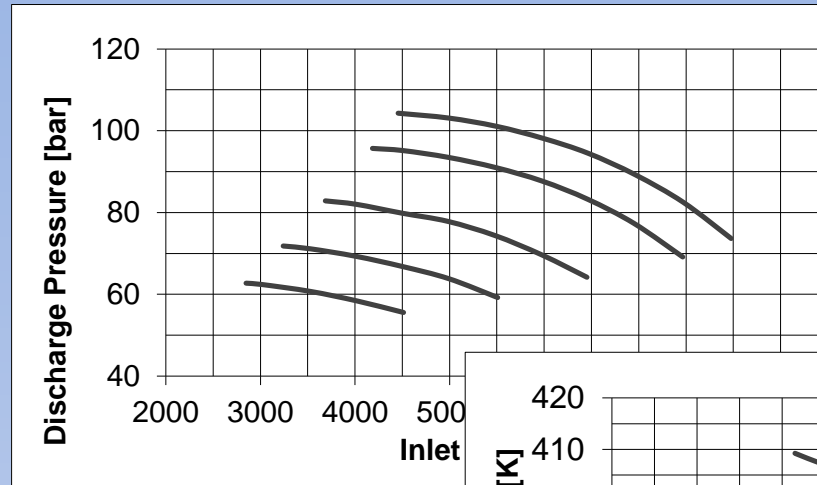
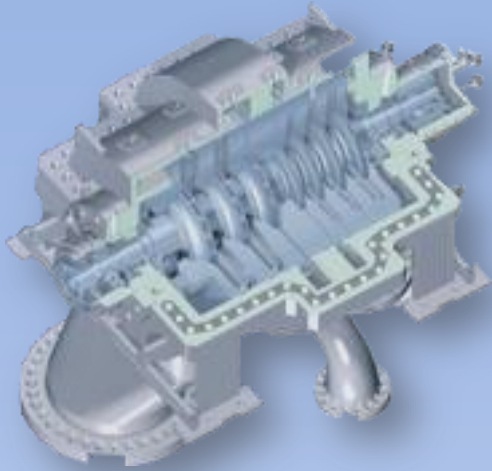


INTRODUCTION AND METHODS OF CMAP SOFTWARE BY IPC-ENG

What is Cmap?

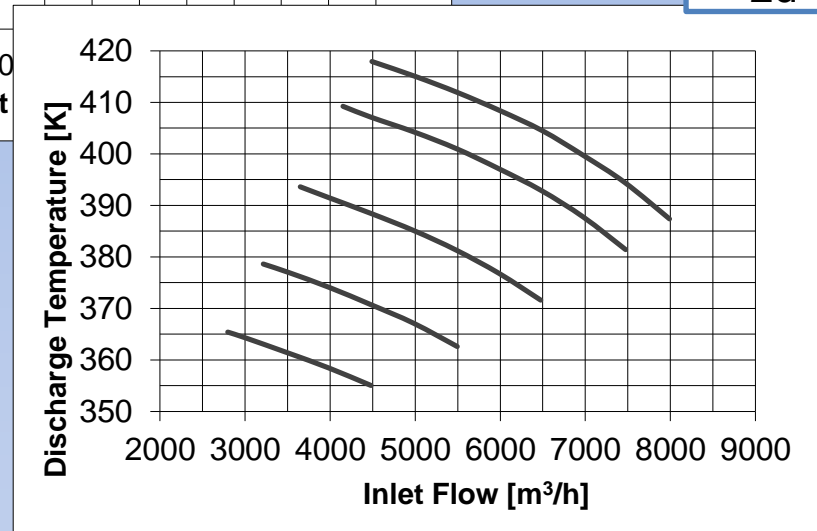
- CMAP is a software designed to perform easily and quickly centrifugal compressors performance evaluations.
- CMAP provides all quantitative information about machine status useful to define diagnostic strategies and maintenance operations.
- The software is easy and intuitive, and will provide also automatic storage of data in a project archives for quick consultation.

Compressor performance



P_{2d}

T_{2d}

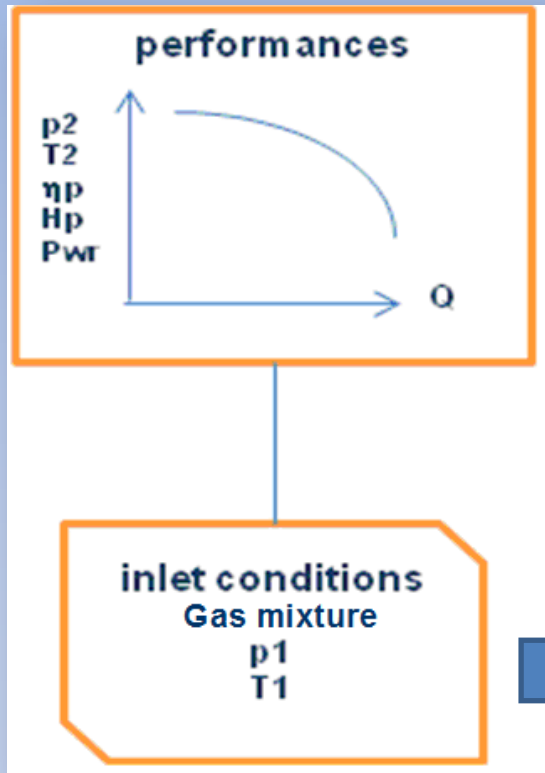


Usually compressor performance are known as set of curves of discharge pressure and discharge temperature as function of inlet volume flow, each set includes many curves each one for a different running speed

Also many times compressor performances are expressed with set of curves of polytropic Head and efficiency vs inlet volume flow, for several operating speed

starting point /statement 1

we can consider that, for a centrifugal compressor, performances are strictly linked to the inlet gas conditions.

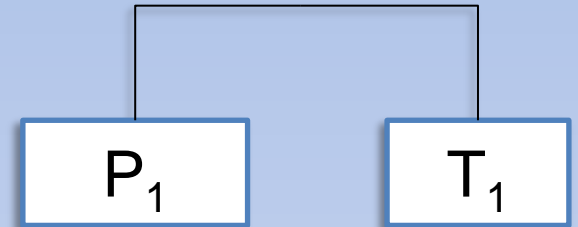


Inlet Gas Mix

Symbol	% mol
Nitrogen	1.46
Methane	80.51
Ethane	14.69
Propane	3.19
i-butane	0.07
n-butane	0.08
Total	100
M (g/mole)	19.24

Inlet Conditions

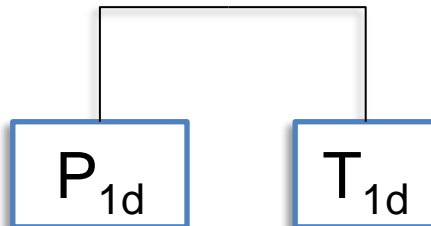
Inlet Thermodin parameters



The **statement 1** applies to all compressor operating conditions and then is valid both for design performances as well for off design/actual performances.

Design/Reference Performances

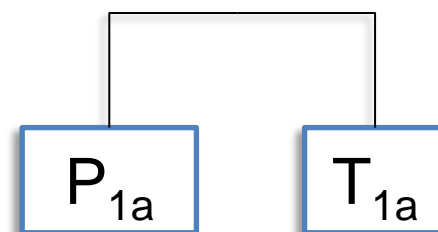
Inlet Design conditions



Symbol	% mol
Nitrogen	1.46
Methane	80.51
Ethane	14.69
Propane	3.19
i-butane	0.07
n-butane	0.08
Total	100
M (g/mole)	19.24

Actual/ofs Performances

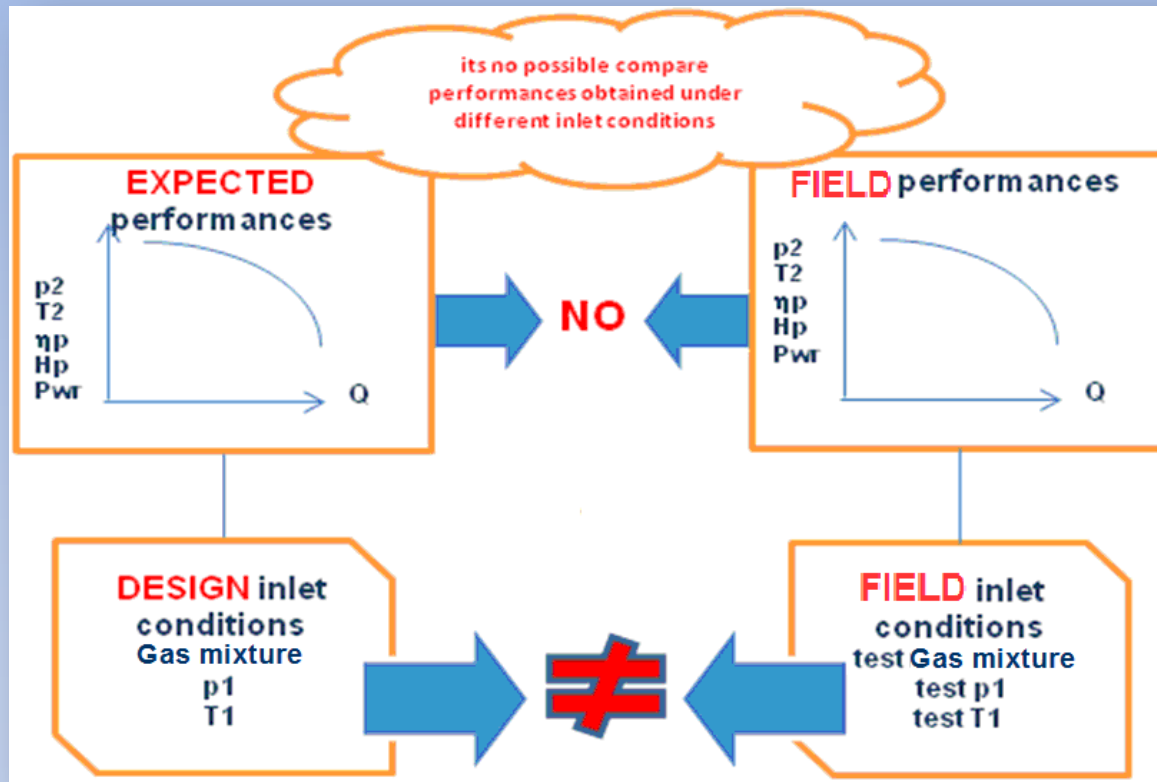
Inlet Actual conditions



Symbol	% mol
Nitrogen	1.46
Methane	80.51
Ethane	14.69
Propane	3.19
i-butane	0.07
n-butane	0.08
Total	100
M (g/mole)	19.24

second point / statement 2

performances referenced to different inlet conditions cannot be in general compared.



Consequently... In general performance may be compared when obtained under the same inlet conditions

In order to compare performances obtained under different inlet conditions it is necessary to adjust and align performances to the same reference inlet conditions.

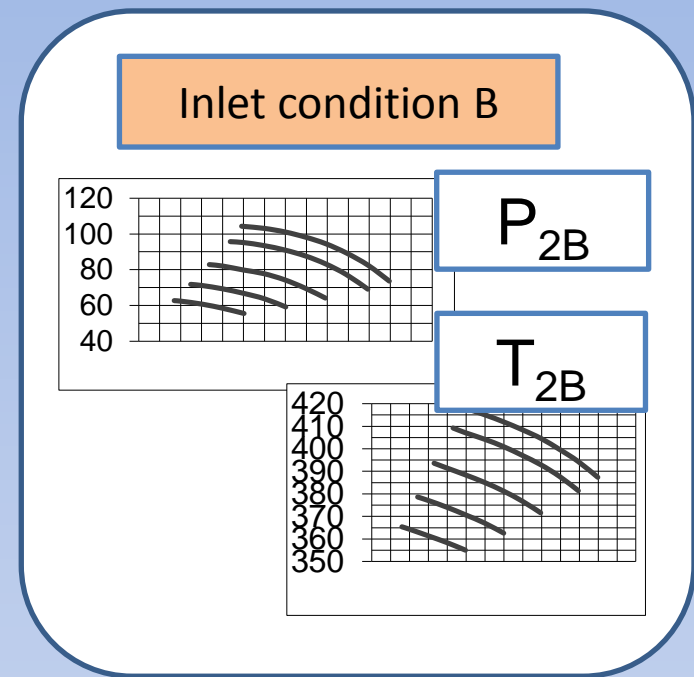
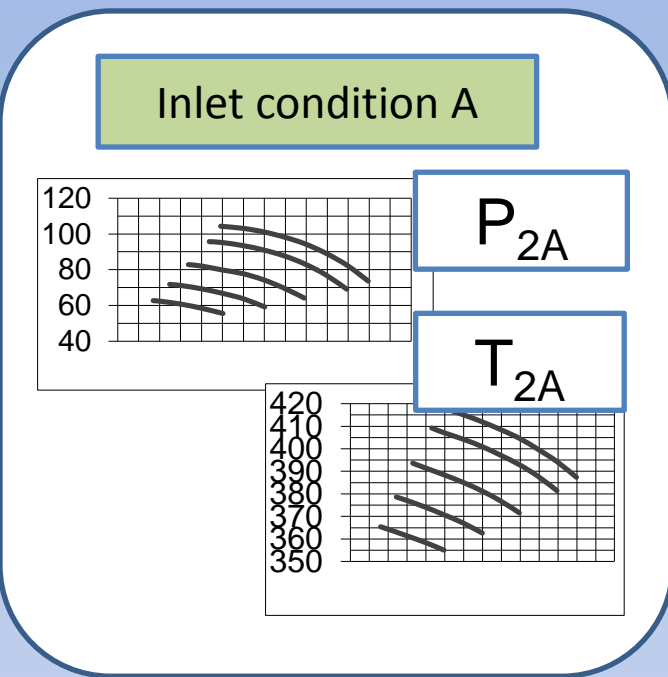
When attempting to evaluating performances by comparison between field measured parameters and reference expected parameters, the special trick is then remember that one of the two performances data set needs to be manipulated and adjusted to the inlet conditions of the second one.

In brief

inlet conditions need to be homogeneous.

What Cmap does

Cmap operates a transformation of performance at a give inlet condition (A) into new performance at new inlet conditions (B)



How Cmap helps the compressor analyst..

- I know the compressor performances in design/reference conditions (and relative inlet design/reference conditions)
- I know also the compressor operating parameters (actual inlet conditions and outlet/performance) in actual conditions.
- Actual inlet condition are different from design inlet conditions

I need to evaluate actual performance and understand if are acceptable and conform to the OEM expectation.

How can I evaluate actual compressor performances?



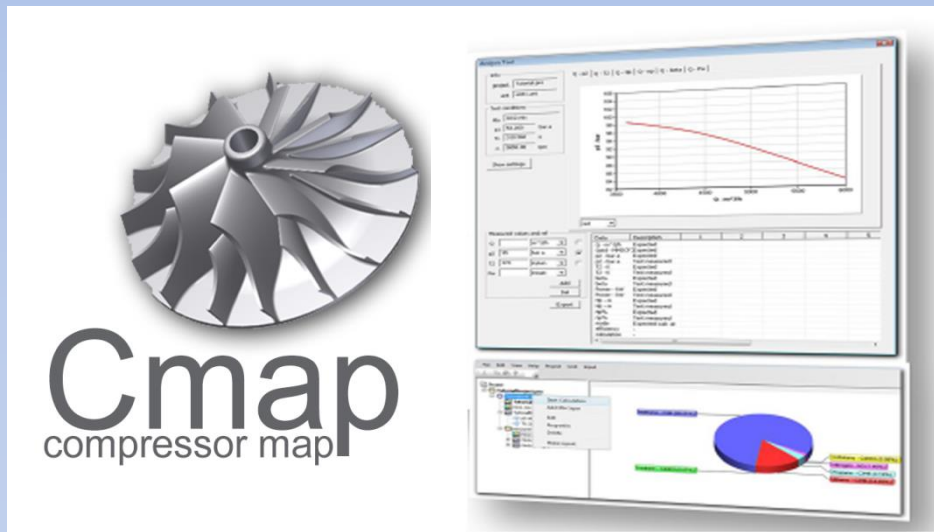
There are 2 possibilities:

A

Adjust Reference maps to actual inlet conditions

B

Adjust actual performance to Reference inlet conditions



Both possibilities can be solved using Cmap

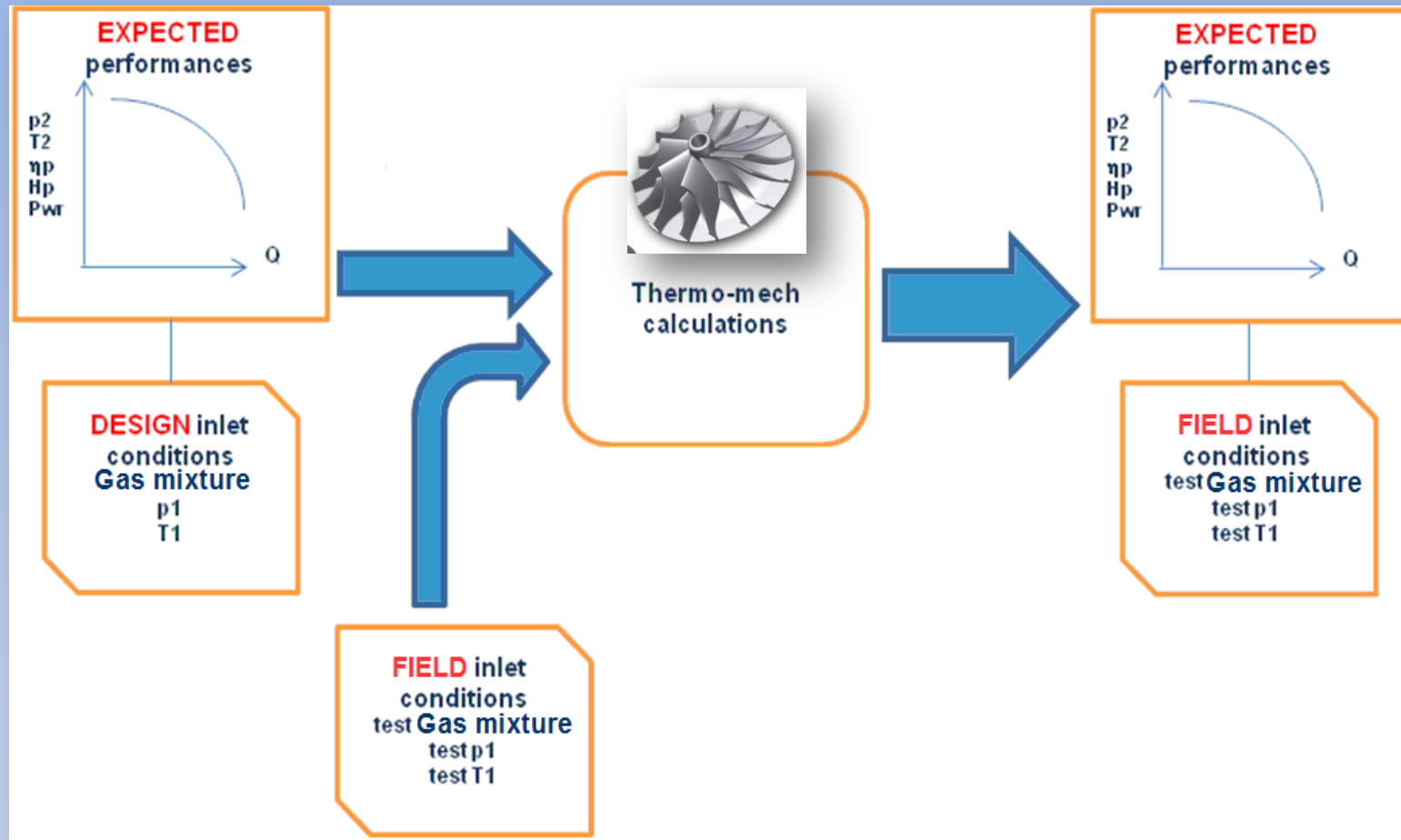
In general we say that Cmap is designed to predict, starting from compressor performance in reference conditions (e.g. design), compressor performance in another different inlet condition (e.g. actual).

In order to evaluate Compressor performance we can apply a method with the following steps:

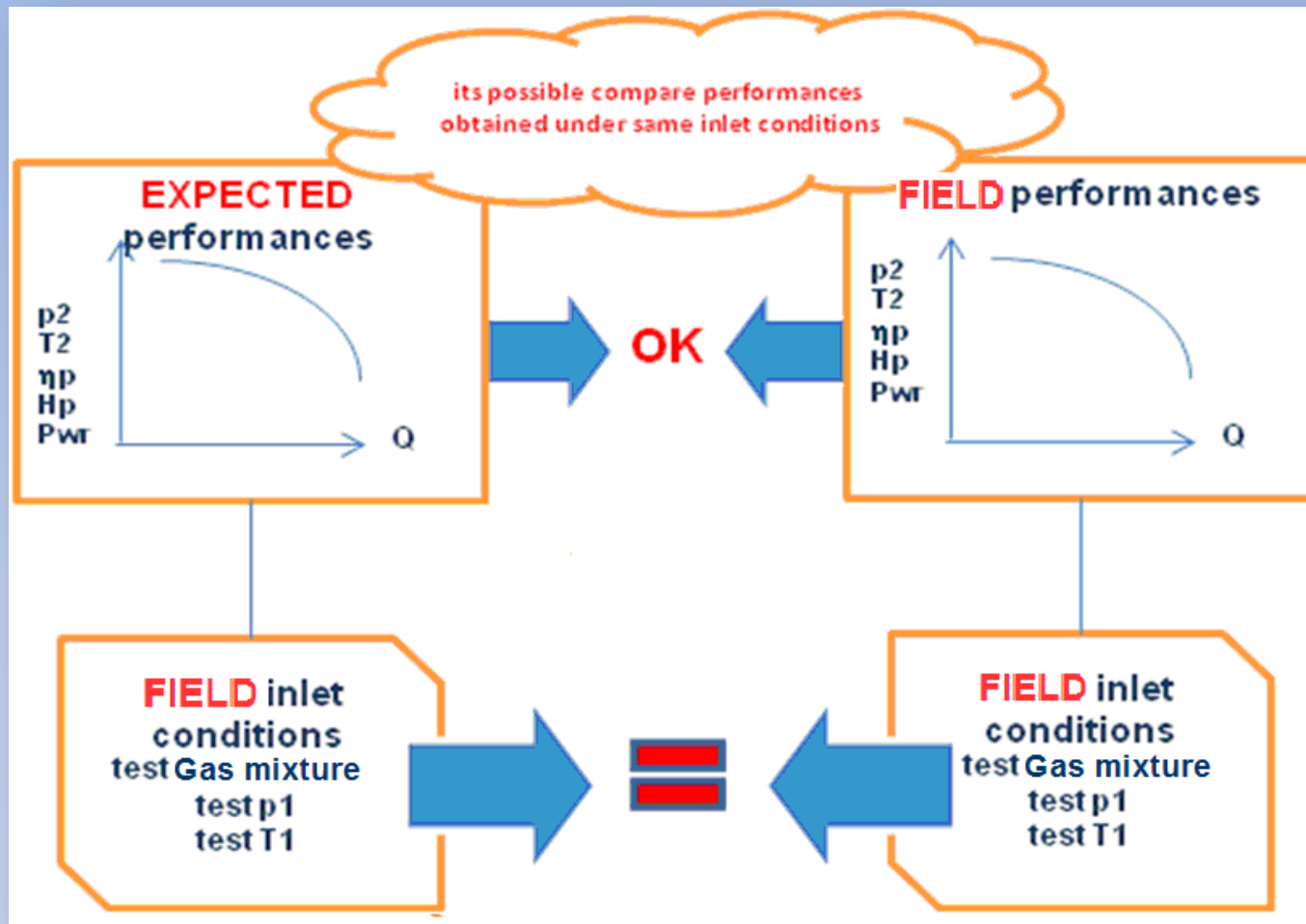
A

- Step1: Adjust Reference/Expected performances (related to reference/design inlet conditions) to actual inlet conditions.
- Step2: compare Actual performance (coming from field measurements) to expected performances (adjusted to actual inlet conditions in the previous step).

How can I predict compressor performances in inlet condition different from design ones?



At this point it's possible to proceed to the comparison of the expected performances to the field performances being both referenced to the same inlet conditions (actual)



In order to use CMAP, the starting point is the **availability of a centrifugal compressor performance map**, along with the relevant gas mix composition and inlet thermodynamic condition (pressure and temperature).

Having this inputs available, the software will perform all complex calculation in fully automated way and will produce the expected compressor performances for inlet pressures, inlet temperatures and gas mix compositions different from design/reference ones.

Some detail more...

The following diagram shows the concept flow chart for overall compressor performance calculations:

Some detail more...

$$\varphi = \frac{Q_1}{\frac{\pi}{4}d_2^2 u_2}$$

$$\psi_p = \frac{gH_p}{u_2^2} = \eta_p \cdot \tau$$

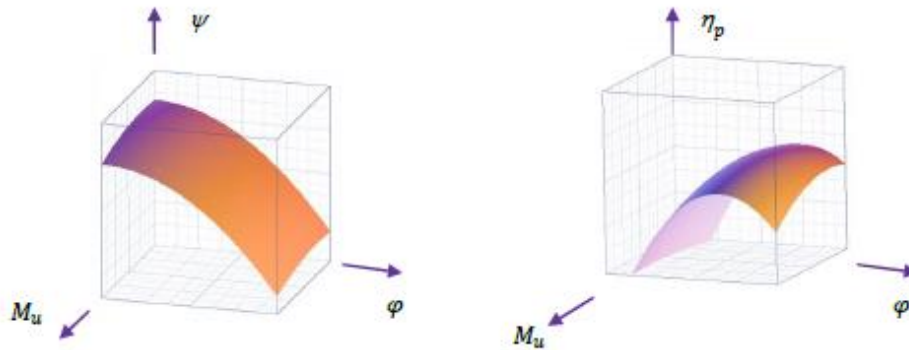
$$R_e = \frac{\rho_1 u_2 b_2}{\mu_1}$$

$$M_u = \frac{u_2}{\sqrt{kZ_1 RT_1}}$$

Starting from machine performances data in reference operative conditions, Cmap is able to build a machine model that captures the character of the machine.

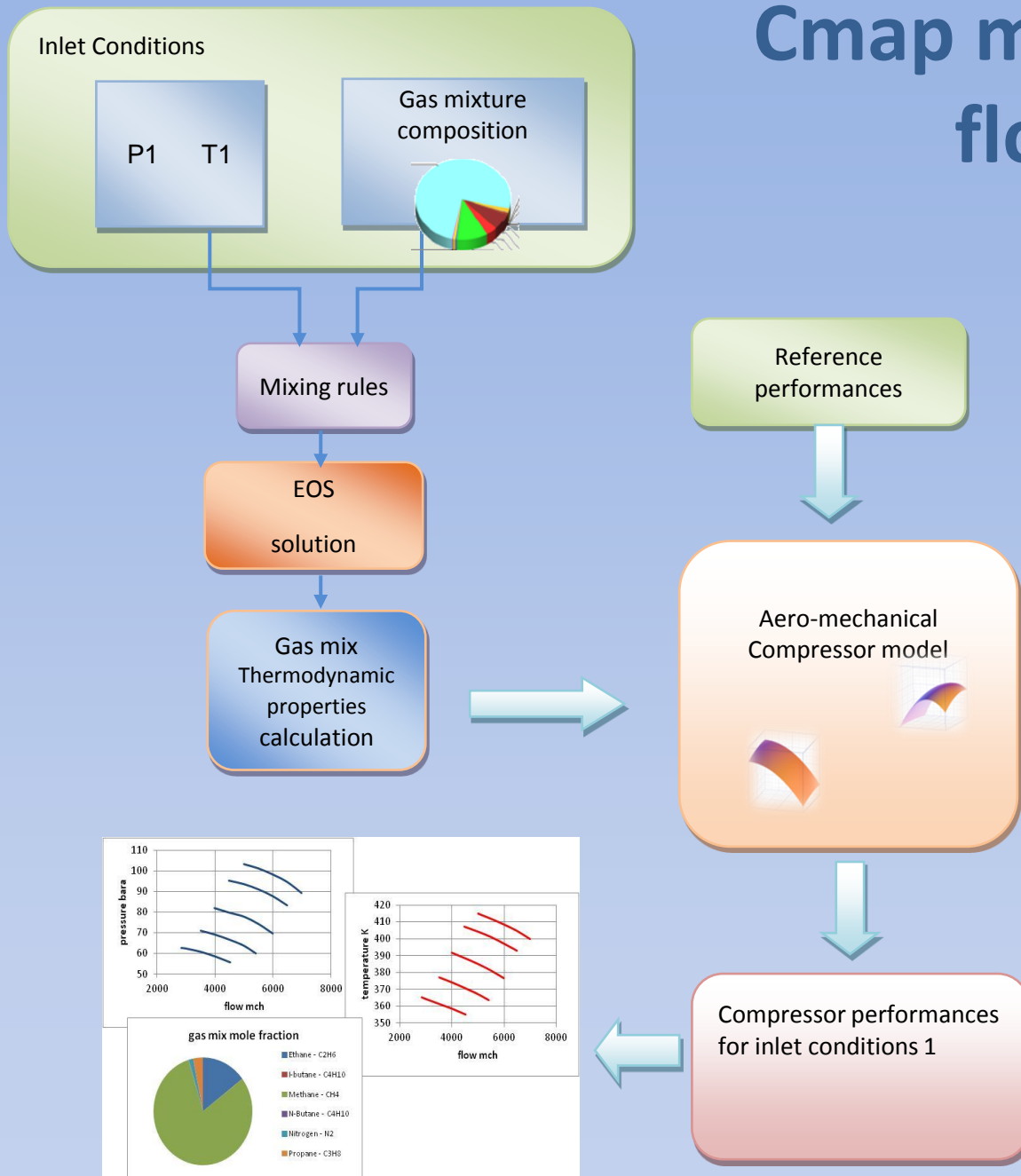
$$p = \begin{Bmatrix} \psi \\ \eta_p \end{Bmatrix} = C[\varphi \quad M_u]$$

Where C is the compressor characterization operator.



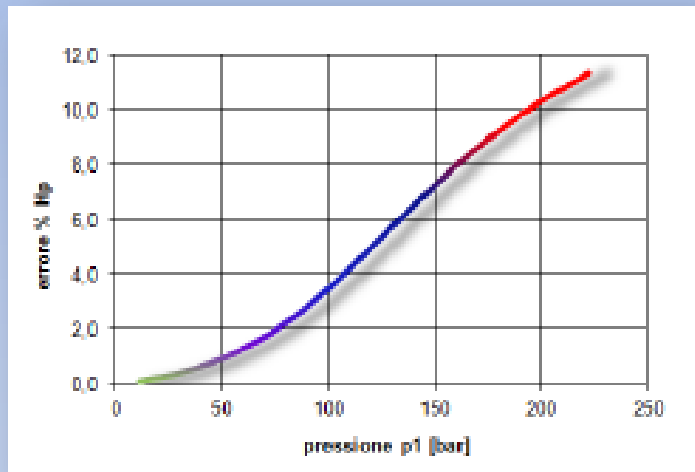
compressor model is characteristic of the machine and represents the invariant base of information upon which it is possible to build the predictions of the compressor performances in operative conditions different from the reference ones

Cmap main algorithm flow chart

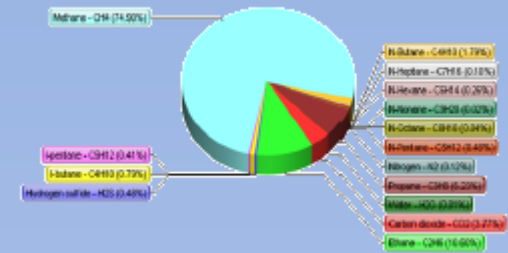


While, when compressibility effect may be considered negligible (low Mach flows), head vs flow curves can be considered constant and can be used with technically acceptable results. Considerable errors can be introduced when the compressibility effect becomes important.

Also more sophisticated maps like the reduced head vs reduced flow curves shown to be inadequate to correctly predict compressor performance in these conditions.



Cmap has been designed in order to provide calculation capability necessary to implement last methods for the centrifugal compressor performances prediction problem.



The Cmap approach, introduces a certain degree of complication from a calculation point of view and necessary calculations steps cannot be developed by hand. Modern computers computational capabilities allow to easily overcome this problems.

<http://www.compressormap.com>

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Cmap
compressor map