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Manual
Gas Quality AFB

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1 About these Instructions

The enCore FC1 manual has a modular design. To get an overview of the enCore/enSuite concept, the structure of the manual, safety and risk instructions, and the text labeling, refer to ⇨ the "Operating Instructions" of the enCore FC manual.

The present volume describes the basic functionalities and operation of the Gas Quality AFB. Parameterization is explained in this document only by way of example as the meaning of individual parameters is documented in detail in the online help of enSuite.

Online help

In enSuite, you can call up the general help via the menu item **Help – Show online help**. Open the context-sensitive help directly from the desired branch in the parameterization window with **[F1]**.

This part of documentation is intended for specialist personnel who are responsible for the service activities of the following tasks after the successful assembly of the device and installation of the current enSuite version on PC:

- adaptation of device parameterization to the measuring task
- test of all data points and commissioning
- other service activities

The illustrations in this manual serve to depict the facts that are being explained, and therefore may differ from the actual design depending on the configuration of the device and enSuite.

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2 Functional Description

The Gas Quality AFB is an **A**pplication **F**unction **B**lock for enCore devices. It calculates the characteristics for flow conversion according to international calculation standards based on a fix parameterized or a measured gas quality. The heating values and density can for instance be calculated according to ISO 6976[1] and the conversion factor C according to the procedures based on AGA8-92 DC and AGA8:2017 (ISO 12213-2), SGERG-88 (ISO 12213-3), AGA-NX19, GOST 30319.2 or GOST 30319.3.[2]

The Gas Quality AFB can be used for various applications and is thus combined with other AFBs.
The most frequent application is the flow conversion: The flow conversion of the enCore FC1 is based on the close interaction of the three software elements – Basic System, Gas Quality AFB and Flow Conversion AFB.
The volume at base conditions V_b is calculated with the help of the gas equation for compressibility:

$$V_b = V_m \times \frac{p}{p_b} \times \frac{T_b}{T} \times \frac{1}{K}$$

Where:

V_m	volume at measurement conditions
V_b	volume at base conditions
p	pressure at measurement conditions
p_b	pressure at base conditions
T	temperature at measurement conditions (in Kelvin)
T_b	temperature at base conditions (in Kelvin)
K	compressibility ratio (K factor)

[1] The AFB supports ISO 6976:1995 and since AFB version 03-13 ISO 6976:2016.
[2] not all calculation methods are available in all enCore FC device types

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The scope of function between the three components is distributed as follows for the flow conversion of the enCore device:

- Basic System
  Comprises the connections, parameterization and management of used measurement devices such as gas meters, pressure and temperature transmitters and, if required, gas quality measurement devices.

  The Basic System prepares the input data. It provides the pressure p, the temperature t and (optionally) the essential gas characteristics to the Gas Quality AFB, and the volume at measurement conditions V_m and the flow rate Q to the Flow Conversion AFB.
  ⇨ chapter 2.1 Defining Measurement Monitoring and Substitution Strategy (Preprocessing) (p. 9)

- Gas Quality AFB
  The Gas Quality AFB can process a measured gas quality as well as constant values, depending on whether or not you are using a gas quality measurement device. The AFB also provides essential gas characteristics, such as density (ρ_m, ρ_b) and volume- and mass-based heating values.

  The Gas Quality AFB calculates the K factor K for the flow conversion based on the behavior of the compressibility factors Z_m and Z_b:

$$K = \frac{Z_m}{Z_b}$$

Where:

Z_m	compressibility factor at measurement conditions
Z_b	compressibility factor at base conditions

It calculates the conversion factor C (C-factor) with the help of state equation and makes it available for Flow Conversion AFB as export value:

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$$C = \frac{p}{p_b} \times \frac{T_b}{T} \times \frac{1}{K}$$

Where:

C conversion factor (C-factor)

⇨ chapter 2 Functional Description (p. 6)

- Flow Conversion AFB

  The Flow Conversion AFB calculates the flown volumes at base conditions V_b, the energy E and the mass M based on the input values from the Basic System and the Gas Quality AFB. The standard calculation method used is as follows:

$$V_b = V_m \times C$$

$$E = V_b \times H_{Vol}$$

$$M = V_b \times \rho_b$$

Where:

H_{Vol} volume-based heating value

ρ_b density at base conditions

The Gas Quality AFB provides the values C, H_{Vol} and ρ_b.

⇨ volume “Flow Conversion AFB” of the enCore FC manual

In order to be able to carry out a flow conversion the enCore FC1 requires at least one Flow Conversion AFB and one Gas Quality AFB, besides the Basic System. This configuration depicts a single-stream operation with one flow direction.

The modularity of device facilitates the realization of various extended operational and technical-measurement requirements. The number of measurement streams and their flow directions which the enCore FC1 can process is variable and is determined by the number of board slots as well as the configuration of hardware and software (⇨ “Operating Instructions” of the enCore FC1).

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Example

For a single-stream operation with two flow directions, you combine, 2 Flow Conversion AFBs with only 1 Gas Quality AFB and one Basic System.

The Gas Quality AFB is divided in the following functional areas:

- ⇨ 2.1 Defining Measurement Monitoring and Substitution Strategy (Preprocessing) (p. 9)
- ⇨ 2.2 Parameterize Input Values and their Base Conditions (Source) (p. 19)
- ⇨ 2.3 Calculating Gas Characteristics (End base conditions) (p. 32)
- ⇨ 2.4 Calculating the Velocity of Sound (Optional) (p. 35)

A workflow depicting the interaction of the individual functional areas is available in ⇨ chapter 2.5.1 Flowchart (p. 37).

2.1 Defining Measurement Monitoring and Substitution Strategy (Preprocessing)

Preprocessing operations allow to react to erroneous measurement inputs with a flexible alarm and substitution strategy, and to replace erroneous values with valid measurements. Additionally you can parameterize limit monitoring.

Monitor every measurand using a preprocessing

We recommend to monitor each measured input value with a preprocessing operation, so that the best possible values are used for the calculations of the Gas Quality AFB in case of an error.

This basically means:

- Avoid using measurements directly as import values for the calculations of the Gas Quality AFB.

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- Instead, manage each of the measured input values of pressure `p` and temperature `t` in a single preprocessing operation, and the gas composition in a preprocessing group (⇨ chapter 2.1.1 Substitution Values and Substitution Strategies, p. 10).
- Import the validated results obtained by the preprocessing operations as the basis for the calculations of the Gas Quality AFB.

The preprocessing operations consist of the following functional areas:

⇨ 2.1.1 Substitution Values and Substitution Strategies (p. 10)
⇨ 2.1.2 Monitoring Warning and Alarm Limits (Optional (p. 16)
⇨ 2.1.3 Results of Preprocessing (p. 18)

2.1.1 Substitution Values and Substitution Strategies

A substitution strategy offers up to six levels for measured input values. The levels are prioritized, thus the value of **Level 1** having the highest and each of the other levels having a lower priority. Moreover, a fixed keypad value has the lowest priority.

A simple substitution strategy is a two-stage operation and consists of one measured input value (**Level 1**) and one **Keypad value**, wherein the keypad value substitutes the measurement if the measured value is erroneous. In case of a multi-level substitution strategy, you can assign up to six redundant measured input values (**Level 1** up to **Level 6**) and one **Keypad value**. An erroneous value is replaced in stages with the next error-free value during the operation. This (error-free) value is used until an error-free value having a higher priority level is provided again.

If all the measured input values of the defined **Level 1** up to **Level 6** are erroneous, then the parameter **Substitute value mode** indicates whether the last valid (and intermediately stored by enCore FC1) measured input value is provided as result – when available – or the parameterized **Keypad value**.

Preprocessing operations always check all parameterized levels 1 to 6 whether the individual values are error-free or erroneous.

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Generally speaking, a level of a single preprocessing operation is considered erroneous in the below stated cases:

- The particular measured input value is internally marked erroneous, e.g. because the transmitter or the input board is defective.
  ⇨ appendix 5.3. Three-digit Error Code (p. 71)
- The input value violates an alarm limit that has been paramterized for this preprocessing operation.
  ⇨ chapter 2.1.2 Monitoring Warning and Alarm Limits (Optional (p. 16)

A level of the preprocessing group (see below) is considered erroneous if at least one value of a particular preprocessing operation is marked errorneous at this level.

The Gas Quality AFB manages preprocessing operations for two different types:

- as single preprocessing operation (folder **Preprocessings**)
  This helps you monitor measured input values that are measured by individual transmitters. 1 to 6 transmitters, which redundantly measure the same physical quantity, are allowed per measurand. Use one preprocessing for pressure `p` and one for temperature `t`, even if your measurement device measures only with one transmitter.
- as preprocessing in the preprocessing group (branch **Preprocessing groups**)
  This helps you simultaneously monitor several measurements which are provided simultaneously by one measurement device. Up to six redundant measurement devices can be used.

  As soon as an erroneous measurement is identified in a level, then not just the affected value but the whole group is shifted to the next level. This way it is ensured that the resulting values for further processing are always belonging together as they are coming from the same measurement device.
  Use the preprocessing group if you are using one or more gas quality measurement devices (e.g. process gas chromatographs).

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Parameterize substitution strategies in enSuite

Parameterize substitution strategies in enSuite

enSuite offers two different view for parameterizing preprocessing operations. Preferably, use the simple view if you only require one level:

- simple views
  Only the parameters for a two-stage substitution strategy are available, i.e one measurement (**Level 1**) and the **Keypad value**. Optionally you can even define limit monitoring.
  This view is directly displayed where you assign an input value to the Gas Quality AFB, e.g. in folder **<Gas Quality AFB>**, section **Measurement conditions**, parameter **p input**.
- detailed view
  All the parameters used for defining a multi-level preprocessing are available in the detailed view. Optionally you can define limit monitoring.
  You open this view in the folder **Preprocessings** or **Preprocessing groups**.

Both types of parameterization are documented in detail in the ⇨ online help. The following documentation decribes the detailed view.

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► To define a new preprocessing operation, first state whether it is an single preprocessing or a preprocessing that belongs to a preprocessing group. As a general rule:

- For pressure p and temperature t respectively add a single preprocessing operation in the folder **Preprocessings** on tab **Parameters**.
- For a gas composition add a single preprocessing operation for each component in the folder **Preprocessing groups** on tab **Parameters**.

The alarm behavior determines when preprocessing operations generate warning and alarm messages at erroneous levels. The preprocessing result is marked as erroneous as soon as an alarm message is generated.

To parameterize the alarm behavior for …

► … *a single preprocessing*, open the desired preprocessing in the folder **Preprocessings** f.i. section **p** or **t**.

OR

► … *the preprocessing group*, open the section **Preprocessing group** (the folder **<Gas Quality AFB>**). The alarm behavior is valid for the entire group.

► Define the sensitivity in the parameter **Alarm behavior** by selecting one of the following entries from the drop-down list:

- **non-sensitive** (*default*)
  - **Warning level <x>**
    A warning is generated for each erroneous level, if at least *one*, but not all levels are erroneous.
  - **Alarm level <x>**
    An alarm is generated for each erroneous level as soon as *all* the levels are erroneous.
- **sensitive**
  - (*Warning messages are not generated.*)
  - **Alarm level <x>**
    An alarm is generated for every erroneous level.
- **deactivated**
  - **Warning level <x>**
    A warning is generated for every erroneous level.
  - (*Alarm messages are not generated.*)

The result of the preprocessing operations is always considered as …

- … error-free
  as long as *only warning messages* are generated.
  The result is considered to be error-free even if the value comes from an erroneous level.

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- … erroneous
  as long as *an alarm message* is generated.
  The result is considered to be erroneous even if the value comes from an error-free level.
  An erroneous result of preprocessing operations is internally marked erroneous, i.e. marked with an error code (⇨ appendix 5.3 Three-digit Error Code, p. 71).

To add a prepocessing…

► … click the plus sign ✚ on tab **Parameters**.

✓ A new **prepocessing <x>** with the corresponding parameters is created.

► Enter a descriptive identifier for preprocessing operations, such as **t** for temperature in the parameter **Name**.

► Select the measurand in the parameter **Physical quantity**, which you want to manage with a preprocessing.
The following measurands are typically relevant for the calculations of a Gas Quality AFB:

- **Absolute pressure**
  preprocessing for pressure `p` at measurement conditions
- **Temperature** (*default*)
  preprocessing for temperature `t` at measurement conditions
- **Molar fraction**
  preprocessing for a gas component, such as methane (CH_4)
  Gas components should be managed in a preprocessing group because they are generally measured as analysis of *one* measurement device (e.g. a process gas chromatograph).

Presetting in case of simple preprocessing

If you define a simple preprocessing directly with one input value, then the parameters **Physical quantity** and **Physical unit** are correctly preset by enSuite. Gas components are thus automatically assigned to the preprocessing group.

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✓ The parameters **Level 1** to **Level 6** are preset with the selected physical quantity symbol:

- pressure values
- temperature values
- a gas component

The subsequent steps for setting up the substitution strategy are described below. The method to be followed for limit monitoring is described in ⇨ chapter 2.1.2 Monitoring Warning and Alarm Limits (Optional (p. 16).

► Import the measurement of the leading transmitter from the Basic System into the parameter **Level 1**.

In an error-free state, the preprocessing takes this value as export value.

► In order to parameterize measurements of redundant transmitters, import these with the desired priority into the parameters **Level 2** to **Level 6**.

All defined levels are always checked during operation.
The preprocessing can use error-free levels as substitution values.

► Enter a plausible substitute value in the parameter **Keypad value**.

► Select from the parameter **Substitute value mode** which of the following values is used, if all the measurements of the defined **Level 1** to **Level 6** are erroneous:

- **Keypad value** (*default*)
  The parameterized constant is used as a substitute value.
- **Last good value**
  The last valid measurement recorded before the error occurred is used as a substitute value.
  If no valid measurement is stored in the enCore FC1 – e.g. because the device was just started –, then the parameterized **Keypad value** is used.

You will find an example of parameterization in the FAQs; it particularly takes into consideration different sensitivity levels of the alarm behavior (⇨ FAQ 4.1 The Alarm Behavior of Preprocessings – an Example, p. 52).

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2.1.2 Monitoring Warning and Alarm Limits (Optional)

You can define additional limit monitoring for every preprocessing. The measurements of the defined **Level 1** to **Level 6** are monitored, but not the **Keypad value**.

The preprocessing differentiates between lower and upper warning and alarm limits. Moreover, a hysteresis can be considered during the limit monitoring to avoid fluttering messages.

To begin with an overview of configuration options of the limit monitoring:

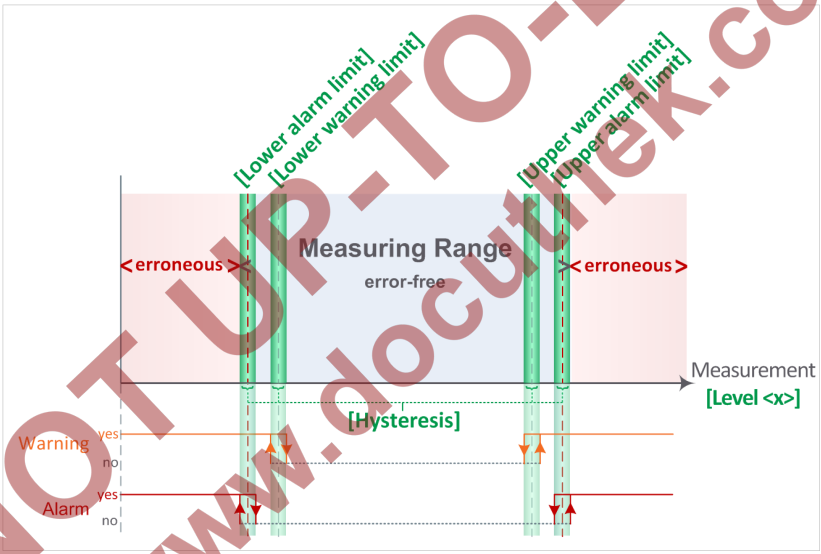

Fig. 2-1: Limit monitoring in the overview

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Parameterizing limit monitoring in enSuite

Activating limit monitoring

The limit monitoring is deactivated by default.
As soon as you set a parameter for limit monitoring to **<Used>** and assign it reasonably, the monitoring for the parameterized values is activated.

For setting alarm limits, …

► … enter the limit for this measurand in the parameters **Upper alarm limit** and/or **Lower alarm limit**.

As soon as a measurement of **Level 1** up to **Level 6** of this preprocessing exceeds the **Upper alarm limit** or falls below the **Lower alarm limit**, the results are:

- This value is considered to be erroneous.
- The level from which this value is taken can no longer be used in the preprocessing as a result, until the alarm limit is no longer violated and the value is re-considered as error-free.
- Use the parameter **Alarm behavior** to decide whether an alarm limit generates a warning **Warning level <x>** or an alarm **Alarm level <x>** in case of violation.

For setting warning limits, …

► … enter the limit for this measurand in the parameters **Upper warning limit** and/or **Lower warning limit**.

As soon as a measurement of this preprocessing exceeds the **Upper warning limit** or falls below the **Lower warning limit**, the result is:

- A **Warning level <x>** message is generated.
- The value of this level is still considered to be error-free and can be used as a result of this preprocessing.

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To consider a tolerance band when reaching the warning and alarm limits, …

► … enter the absolute tolerance value in the parameter **Hysteresis**.

An upper warning respectively an upper alarm limit is considered to be violated only if the measurement exceeds the value **<defined limit>** + (plus) **Hysteresis**. The limit violation is reset only when the measurement falls below the value **<defined limit>** – (minus) **Hysteresis**.
The reverse rule is applicable for lower warning respectively lower alarm limits.

2.1.3 Results of Preprocessing Operations

Preprocessings provide their results as export values:

Symbol	Identifier	Description
<sym.>	**Value**	result of a preprocessing for …
	Value	• … pressure `p` ⇨ import value for section **Measurement conditions**, parameter **p input**
	Value	• … temperature `t` ⇨ import value for section **Measurement conditions**, parameter **t input**
	Value	• … a molar fraction `<chemical molecular formula>`, e.g. N_2, CO_2 ⇨ import value for folder **Gas components**
#	**Level**	Level specifications (digit), that provides the preprocessing result. Value range: **1** to **7** (**Level 1** up to **Level 6**, **7** ≙ **Keypad value**)

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2.2 Parameterize Input Values and their Base Conditions (Source)

Essential information on base conditions

In case of condition-dependent input values the Gas Quality AFB differentiates between base conditions, that are applicable for the gas quality measurement device (≙ source) and the end base conditions that are to be applied for the calculations of the enCore FC1.

⇨ FAQ 4.3 For a Better Understanding: Base Conditions for Calculating Heating Value and Density at Base Conditions (p. 57)

For the calculations of the conversion factor C on the basis of K factor K and compressibility factors (Z_m, Z_b) the Gas Quality AFB requires details on the gas quality, the measurement conditions (t, p) as well as specifications to source and end base conditions.

The Gas Quality AFB calculates K-factor and compressibility factor (Z_m, Z_b) according to the international procedures such as AGA8-DC92, AGA8:2017, SGERG88 or different AGA-NX19 as well as GOST 30319 variants. These procedures require different input values for calculating the compressibility factor (Z_m, Z_b). Prior to the calculation acc. to AGA8-DC92 and AGA8:2017 a check of the input range limits can be performed in accordance to ISO 12213-2:2006.
Alternatively, you can parameterize the Gas Quality AFB in such a way that it uses a constant for the quotients from the compressibility factors (Z_m, Z_b) for all the further calculations.

At first, define the calculation method, then systematically parameterize the required input values and the applicable base conditions for the selected procedures:

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Parameterizing the calculation methods in enSuite

Parameterization of base conditions of the gas quality measurement device in Gas Quality AFB

Ensure that the base conditions of the gas quality source parameterized in the enCore FC is actually coincide with the base conditions being valid for the measurements of the gas quality measurement device (e.g. a process gas chromatograph).

► Open the section **Calculation methods** (in folder **<Gas Quality AFB>**).

► Select the method for calculating the compressibility factor Z_m at measurement conditions from the drop-down list **Z_m calculation method**:

- **AGA8-DC92** and **AGA8:2017** (ISO 12213-2)
  This method requires the following input values:
  – temperature at measurement conditions t
  – pressure at measurement conditions p
  – gas composition with 22 components
  (i.e. a complete and normalized gas vector)

  ⇨ Select this procedure if the measurement device carries out a detailed gas analysis, such as the process gas chromatograph EnCal 3000.

- **SGERG-88 <ρ_b/rd> [H_sV] <gas component[s]>** (ISO 12213-3)
  There is a range of different SGERG-88 variants, which require different input values (⇨ appendix 5.2.2 Required Input Values and their Parameterization, p. 70).

  ⇨ Investigate which mesurements are provided by the used measurement device. Based on this information, select a suitableSGERG-88 procedure; all required input must be availabe. When you use, for instance, the gas-lab Q1, select the entry **SGERG-88 ρ_b H_sV CO_2**.

- **AGA-NX19** variants
  The AGA-NX19 variants require different input values (⇨ appendix 5.2.2 Required Input Values and their Parameterization, p. 70).

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AGA-NX19 GOST and GOST 30319 variants are defined only for one end base conditions

Note: **AGA-NX19 GOST**, **GOST 30319.2** and **GOST 30319.2** procedure has exclusively been defined for the following end conditions of ISO 6976:

- combustion temperature $t_{comb.} = 20\ °C$
- base temperature $t_b = 20\ °C$
- base pressure $p_b = 1.01325\ bar$

⇨ chapter 2.3 Calculating Gas Characteristics (End base conditions) (p. 32)

- **GOST 30319.2** (2015)
  This method requires the following input values:
  – temperature at measurement conditions t
  – pressure at measurement conditions p
  – density at base conditions ρ_b
  – nitrogen N_2
  – carbon dioxide CO_2
- **GOST 30319.3** (2015)
  This method requires the following input values:
  – temperature at measurement conditions t
  – pressure at measurement conditions p

  gas composition with 15 components (i.e. a complete and normalized gas vector):
  – methane CH_4
  – ethane C_2H_6
  – propane C_3H_8
  – isobutane $iso\text{-}C_4H_{10}$
  – n-butane $n\text{-}C_4H_{10}$
  – isopentane $iso\text{-}C_5H_{12}$

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- n-pentane $n\text{-}C_5H_{12}$
- hexane C_6H_{14}
- nitrogen N_2
- carbon dioxide CO_2
- helium He
- argon Ar

⇨ Select this procedure if the measurement device carries out a detailed gas analysis, such as the process gas chromatograph EnCal 3000.

- **use Z_m/Z_b substitute value**
  In this case, Z_m and Z_b are not calculated. The parameterized fixed value is used for all the following calculations for the quotients $Z_m/Z_b = C$.

> **"use Z_m/Z_b substitute value" always has an effect on both the parameters "Z_m/Z_b calculation method"**
>
> The setting **use Z_m/Z_b substitute value** is advisable only if you use it for both the parameters **Z_m calculation method** as well as for **Z_b calculation method**.

To check input range limits prior to the calculation acc. to AGA8-DC92, AGA8:2017 or GOST 30319.3 in accordance to ISO 12213-2:2006 or GOST 30319.3-2015, respectively, ...

▶ ... select the checkbox **Z_m, Z_b calculation input check**.

In case the limit for at least one of the input vector values is exceeded, the alarm **C calculation error** is generated. The **Z_m/Z_b substitute value** is used as result of the C calculation instead.

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► Select the procedure for calculating the compressibility factor Z_b at base conditions from the drop-down list **Z_b calculation method** – generally you select the same setting here as already used for **Z_m calculation method**.
There is one more *additional* procedure provided as an option:

- **ISO 6976/GPA 2172**
  These procedures require the following input values:
  – temperature at measurement conditions t
  – pressure at measurement conditions p
  – gas composition with 22 components
  (i.e. a complete and normalized gas vector)
  ⇨ This procedure is advisable only if you have selected AGA8-92DC as **Z_m calculation method**.
- (⇨see above drop-down list **Z_m calculation method**)

Z_b calculation according to ISO 6976 or GPA 2172

If you select the **ISO 6976/GPA 2172** procedure for the Z_b calculation, then you need to define whether the calculation is done according to ISO 6976:1995, ISO 6976:2016 or GPA 2172 in section **End base conditions** using the parameter **Standard used**.

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2.2.1 Pressure p, Temperature t and Gas Composition

Parameterize all necessary input values

Check whether you have parameterized all necessary input values for the selected calculation method. Any deviating settings can lead to non-verifiable results.

If required, you will find a tabular overview on the necessary input values and the corresponding parameters in the appendix (⇨ appendix 5.2.2 Required Input Values and their Parameterization, p. 70).

All calculation methods require the input variables temperature t, pressure p and different gas quality values.
The Gas Quality AFB can include an input vector of up to 22 gas components in the calculations. It carries out a normalization by default in case a complete gas vector is present; you can selectively exclude individual components from the normalization.

Prerequisite for normalization is a complete gas vector

It can be normalized only if there is a complete gas analysis available. An absolute prerequisite for the normalization is a known methane (CH_4) proportion.

Calculation methods, which assume the availability of a complete and normalized gas vector – AGA8DC92, AGA8:2017, ISO 6976, GPA 2172, GOST 30319.3 or AGA10 – cannot be carried out if there is *no* complete gas analysis.

If the prerequisites for a normalization are fulfilled, then it is carried out automatically, because the sum of all the components for further calculations must exactly result in 100 mol% according to AGA8-DC92, AGA8:2017, ISO 6976 or GPA 2172. If required, you can selectively exclude individual components from the normalization.

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The automatic normalization is deactivated as soon as you set the component methane (CH_4) as **<Not used>** or **not assigned**.

Particularity for GOST 30319.3

For calculations according to GOST 30319.3 following gas components are summed:

$C_6H_{14} = C_6H_{14} + C_7H_{16} + C_8H_{18}$

$N_2 = N_2 + CO_2 + AR$

Parameterizing input values in enSuite

In order to parameterize input values, …

► … open the folder **Gas components**.

✓ A gas vector with 22 components is displayed on the tab **Gas components** in the tabular view.

Tabular view vs. detailed view

There are two views in order to parameterize the gas components:

- The overall gas vector is given in an tabular overview on tab **Gas components**. You can edit all the components simultaneously or individually.
- You will see the configuration options for the selected gas components in the detailed view on tab **Parameters**. Moreover, you can configure treatment of the neopentane components ($neo\text{-}C_5H_{12}$) and hexane (C_6H_{14}) .
  ⇨ 4 FAQ (p. 52)

The following documentation describes the tabular view only.

For every gas component, state whether the input value is an import or a constant value, or if there is no value present:

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► Click on the desired button in the upper region of the tab in order to change the type of the input value for *all* gas components simultaneously:
OR
Activate one of the checkboxes in the context menu to change the type of the input value for *one* selected gas component:

- **Import**
  Select this setting in order to import a current measurement.
- **Constant**
  Select this setting in order to enter a constant value.
- **Not used**
  Select this setting if neither an import nor a constant value is provided.

✓ If you have selected the type **Constant** for one or all the parameters, then the column **Input** is preset *exemplary* with the values of a typical natural gas analysis.

► Parameterize the corresponding input values in the column **Input**:

- Import the corresponding values of the gas quality for every affected component – ideally the result of a preprocessing.

OR

- Enter a constant, which corresponds to its fraction in the gas composition, for every affected component.

► For every component define whether it shall be included in the normalization or not Activate resp. deactivate the checkboxes in column **To be entered into normalization** – normalization is activated by default.

For all parameterized input values, the related components are made available as (if applicable normalized) export values.

These results are used in the Gas Quality AFB for all the subsequent calculations.

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In order to add the input values at measurement conditions (p, t), …

- ► … open the folder **<Gas Quality AFB>** and the section **Measurement conditions**.
- ► Activate, if necessary, the entry **Import** in the context menu of parameter **p input** in order to parameterize the input value for pressure p.
- ► Import into the column **Value** either the current measurement from the Basic System or ideally the result of the preprocessing for the pressure transmitter(s).
- ✓ The input value for pressure p is parameterized.

Proceed in the same way in order to parameterize the input value for temperature t:

- ► Activate the entry **Import**, if necessary, in the context menu of parameter **t input**.
- ► Import into the column **Value** either the current measurement from the Basic System or ideally the result of the preprocessing for the temperature transmitter(s).
- ✓ The input value for temperature t is parameterized.

2.2.2 Density ρ_b, Relative Density rd and Heating Values at Base Conditions (Source)

The Gas Quality AFB can calculate the density, the relative density as well as different heating values (relative to the base conditions of the gas quality source) according to ISO 6976[3], GPA 2172, AGA8-DC92, AGA8:2017 and GOST 30319.3. The prerequisite is a complete and normalized gas vector.

You can import these values if the gas quality measurement device used provides the density, relative density or heating values at base conditions. If the density ρ_b is provided at base conditions or the relative density rd as an input value, the Gas Quality AFB calculates a value of the other.

[3] The AFB supports ISO 6976:1995 and since AFB version 03-13 ISO 6976:2016.

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Parameterize base conditions of the gas quality source in enSuite

► Open in the folder **<Gas Quality AFB>** the section **Base conditions GQ source**.

► Select the prevailing base conditions of the gas quality source from the drop-down list **Standard used**. The entries either correspond with the ISO 6976 or the GPA 2172:

- **(<combustion temperature $t_{comb.}$>, <temperature at base conditions t_b>) °C, 1.01325 bar (ISO)**
  According to ISO 6976, the combustion temperature and temperature at base conditions t_b vary; the pressure at base conditions p_b is constant at 1.01325 bar.
- **60 °F, <pressure at base conditions p_b> (GPA)**
  According to GPA 2172, combustion temperature and temperature at base conditions t_b are constant at 60 °F; the entries vary depending on the prevailing pressure at base conditions p_b.

The following values of gas are calculated based on the selected base conditions if a complete, normalized gas vector is present:

- Calculations according to ISO 6976:1995, ISO 6976:2016 or GPA 2172 are provided as export values in folder **ISO 6976/ GPA 2172**:
  - density at base conditions $\rho_{b\ calc.}$
  - relative density $rd_{calc.}$
  - gross volume-based heating value $H_sV_{calc.}$
  - net volume-based heating value $H_iV_{calc.}$
  - gross mass-based heating value $H_sM_{calc.}$
  - net mass-based heating value $H_iM_{calc.}$
  - gross Wobbe index $W_{s\ calc.}$
  - net Wobbe index $W_{i\ calc.}$
- Calculations according to AGA8 are provided as export values in the folder corresponding folder **AGA8-DC92** or **AGA8:2017**:
  - compressibility factor at base conditions $Z_{b\ AGA8}$
    This value refers to the base conditions of the *end* base

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conditions (section **End base conditions**, parameter **Standard used**).

– density at base conditions $\rho_{b\ AGA8}$

– relative density rd_{AGA8}

- Calculations according to GOST 30319.3 are provided as export values in folder **GOST 30319.3**:

  – compressibility factor at base conditions $Z_{b\ GOST}$
  This value refers to the base conditions of the *end* base conditions (section **End base conditions**, parameter **Standard used**).

  – density at base conditions $\rho_{b\ GOST}$

OR

If there is no complete gas vector, all the export values in the folders **ISO 6976/GPA 2172**, **AGA8-DC92**, **AGA8:2017** and **GOST 30319.3** are marked internally as non-usable.

In this case, do not use these export values as import values, because the subsequent calculations will be erroneous.

In order to parameterize the density at base conditions ρ_b and/or the relative density rd relatively to the base conditions of the gas quality source, …

► … open in folder **Base conditions GQ source** the section **Density**.

✓ The following input values are available:

- **ρ_b input** density at base conditions ρ_b
- **rd input** relative density rd

► Activate the entry **Import** or **Constant** in the context menu of parameter in order to parameterize an input value.

► Import one of the following values into the column **Value** in order to parameterize an import value:

- the current measurement either from the Basic System or ideally the result of the preprocessing for density measurements
- the calculated value from the folder **ISO 6976/GPA 2172**
- the calculated value from the folder **AGA8-DC92 or AGA8:2017**

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OR

Enter the corresponding value in the column **Value** in order to parameterize a constant.

► Repeat this procedure if required for the second parameter.

The Gas Quality AFB calculates the following export values based on the parameterized input values **ρ_b input** and **rd input**:

- **rd via ρ_b**

  The relative density rd is calculated from the input value **ρ_b input** (density at base conditions) and the density of air at base conditions.

$$rd = \frac{\rho_b}{\rho_{b\,air}}$$

  Where:

rd	relative density
ρ_b	density of the natural gas at base conditions
$\rho_{b\,air}$	density of air at the same base conditions

  If the input value **ρ_b input** is not parameterized or erroneous, **rd via ρ_b** is marked as erroneous.

- **ρ_b via rd**

  The density at base conditions ρ_b is calculated using the input value **rd input** (relative density) and the density of air at base conditions.

$$\rho_b = rd \times \rho_{b\,air}$$

  If the input value **rd input** is not parameterized or erroneous, **ρ_b via rd** is marked as erroneous.

Calculated value for density at base conditions ρ_b or relative density rd

The export values **ρ_b via rd** and **rd via ρ_b** refer to the base conditions of the gas quality source (folder **<Gas Quality AFB>**, section **Base conditions GQ source**, parameter **Standard used**) and can be used as alternative input values.

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This is useful, for instance, ifrequire the input value for the density at base conditions is required for the selected **Z_m/Z_b calculation method** and the gas quality measurement device provides only the relative density. In this case, you can parameterize the calculated value **ρ_b via rd** for the base density input. Consider that every necessary input value must actually be assigned, otherwise an alarm will be generated. Internally calculated values are not used automatically!

If input values are available for heating values referring to the base conditions of the gas quality source, …

► … open the section **Heating values**.

✓ You can parameterize the following input values:

- **H_sV input** gross volume-based heating value H_sV
- **H_iV input** net volume-based heating value H_iV
- **H_sM input** gross mass-based heating value H_sM
- **H_iM input** net mass-based heating value H_iM
- **W_s input** gross Wobbe index W_s
- **W_i input** net Wobbe index W_i

► Activate the entry **Import** or **Constant** in the context menu of a parameter in order to parameterize an input value.

✓ The column **Value** is preset *exemplary* with a value as soon as you select the type **Constant** for a parameter – this value matches with the exemplary preset values in the folder **Gas components**.

► Import one of the following values in the column **Value** in order to parameterize an import value:

- the current measurement either from the Basic System or ideally the result of the preprocessing for heating value measurements
- the calculated value from the folder **ISO 6976/GPA 2172**
- the calculated value from the folder **AGA8-DC92** or **AGA8:2017**
- the calculated value from the folder **GOST 30319.3**

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OR
In order to parameterize a constant, enter the corresponding value in the column **Value**.

► Repeat this procedure if required for all the other parameters.

2.3 Calculating Gas Characteristics (End base conditions)

The values for base pressure p_b and base temperature t_b from the end base conditions are entering the calculation of the compressibility factor Z_b, the K factor K and the conversion factor C. If necessary, you can parameterize two end base conditions:

For the first end base conditions (folder **<Gas Quality AFB>**, section **End base conditions**) select one of the specified constant base conditions – analogous to the base conditions of the gas quality source. All selectable base conditions are considered in the ISO 6976 or GPA 2172 and are used for the subsequent calculations of the gas characteristics. The results can be used for fiscal purposes.

Special case: If the specified constant base conditions of the first end base conditions are not sufficient, then the Gas Quality AFB offers the option to define a second end base conditions for the enCore FC1 (section **2nd end base conditions**). Here you can freely define the base conditions (t_b, p_b). However, the results based on the second end base conditions can*not* be used for fiscal purposes.

Base conditions of the gas quality measurement device and of the enCore FC1

If the gas quality measurement device (section **Base conditions GQ source**) and the calculations of the enCore FC1 (section **End base conditions**) refer to the same base conditions, then select the same base conditions in the parameter **Standard used**.

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Parameterizing base conditions of enCore FC1 in enSuite

Define the first end base conditions:

► Open in the folder **<Gas Quality AFB>** the section **End base conditions**.

► Select the base conditions of the device applicable for the result in the drop-down list **Standard used**. The entries either correspond with the ISO 6976:1995, ISO 6976:2016 or the GPA 2172:

- **(<combustion temperature $t_{comb.}$>, <temperature at base conditions t_b>) °C, 1.01325 bar (ISO:1995)**
  According to ISO 6976:1995, the combustion temperature and temperature at base conditions t_b varies; the pressure at base conditions p_b is constant at 1.01325 bar.
- **(<combustion temperature $t_{comb.}$>, <temperature at base conditions t_b>) °C, 1.01325 bar (ISO:2016)**
  According to ISO 6976:2016, the combustion temperature and temperature at base conditions t_b varies; the pressure at base conditions p_b is constant at 1.01325 bar.

AGA-NX19 GOST and GOST und GOST 30319 variants are defined only for the end base conditions "(20, 20) °C, 1.01325 bar (ISO)"

If the compressibility factor Z_b has to be calculated at base conditions according to AGA-NX19 GOST, GOST 30319.2 or GOST 30319.3 (section **Calculation methods**, parameter **Z_b calculation method**), then select the entry **(20, 20) °C, 1.01325 bar (ISO)** as end base conditions because this procedure is exclusively defined for this base conditions of ISO 6976.

- **60 °F, <pressure at base conditions p_b> (GPA)**
  According to GPA 2172, the temperature at base conditions t_b is constant at 60 °F; the entries vary depending on the prevailing pressure at base conditions p_b.

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The gas characteristics are calculated based on the parameterized base conditions either according to ISO 6976 or GPA 2172.

✓ The export values in the folder **End base conditions** can be imported by other AFBs. Typically the following export values are thus required by the corresponding Flow Conversion AFB:

- conversion factor **C**
- density at base conditions ρ_b
- gross volume-based heating value H_sV
  OR
  gross mass-based heating value H_sM

In order to use a second, variable end base condition, …

► … open the section **2nd end base conditions**.

► Select the entry **Used** from the drop-down list **2nd end base conditions**.

✓ The parameters to define a second base conditions are shown.

► In order to parameterize the prevailing temperature at base conditions t_b, enter the desired constant in the parameter t_b.
OR
Deactivate the checkbox **Used** in the context menu of the parameter t_b.

► If necessary, adapt the physical unit.

► In order to parameterize the valid pressure at base conditions p_b, enter the desired constant in the parameter p_b.
OR
Deactivate the checkbox **Used** in the context menu of the parameter p_b.

► If necessary, adapt the physical unit.

✓ The parameterized base conditions is the basis for all the further calculations; if the parameter t_b or p_b is deactivated then the parameterized value is used for this variable from the first end base conditions.

In the following cases, a substitute value is used for the quotient from the compressibility factors (Z_m/Z_b):

- In the section **Calculation methods** the setting **use Z_m/Z_b substitute value** is parameterized for the **Z_m calculation method** and/or the **Z_b calculation method**.

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- Due to inconsistent or erroneous input values, it is not possible to calculate the compressibility factors (Z_m, Z_b) according to the parameterized procedures.

► If required, change the preset value in the parameter **Z_m/Z_b substitute value** – default is **1.0**.

In the aforementioned cases, this substitue value is used for all the further calculations.

The gas characteristics are calculated based on the parameterized base conditions.
The export values in the folder **2nd end base conditions** can be imported by other AFBs. The same specific values are provided as in the folder **End base conditions** – however, these values cannot be used for fiscal purposes.

Specialty: calculating the compressibility factor Z_b

If the compressibility factor Z_b has to be calculated at base conditions according to ISO 6976 or GPA 2172 (section **Calculation methods**, parameter **Z_b calculation method**), but the parameterized second base conditions do not correspond to the selected standard, then the compressibility factor Z_b is calculated according to AGA8-DC92 or AGA8:2017.

2.4 Calculating the Velocity of Sound (Optional)

The Gas Quality AFB offers the option to calculate the sound velocity (**V**elocity **O**f **S**ound, abbreviated as: VOS) in natural gas according to either the AGA10, AGA8:2017, GOST 30319.2, or GOST 30319.3 procedures. The standard used depends on the method parameterized for calculating the compressibility factor Z_b:

If **Zm calculation method** is ...

- **AGA8-DC92**, then AGA10 is used.
- **AGA8:2017**, then AGA8:2017 is used.
- **GOST 30319.2**, then GOST 30319.2 is used.
- **GOST 30319.3**, then GOST 30319.3 is used.

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This calculation is advisable only if you use a measurement device for velocity of sound, e.g. an ultra-sound meter, and you want to carry out a VOS comparison between the measured velocity of sound and the velocity of sound calculated according to AGA10, AGA8:2017 or GOST 30319.3. The VOS comparison is carried out by Station AFB.

Activate VOS in enSuite

Since the VOS calculation according is advisable only for specific applications, it is deactivated by default.

Prerequisite:

- The following input values are parameterized for the Gas Quality AFB in the folder **<device> – [<Group> –] <Gas Quality AFB>**:
  - complete gas vector (methane (MH_4) must be available): folder **Gas components**
  - measurement for pressure p: section **Measurement conditions**, parameter **p input**
  - measurement for temperature t: section **Measurement conditions**, parameter **t input**
- The desired parameterization is opened in the branch **<device> – <Gas Quality AFB>**.

► Open the section **VOS**.

► Select the entry **Used** on tab **Parameters** from the drop-down list **VOS**.

The calculation of the velocity of sound is activated and provides the following export values:

- **VOS**
  Velocity of sound.
  The Station AFB needs this value for the VOS comparison as import value (branch **<Station AFB>**, section **VOS comparison**, parameter **Calculated VOS (input)**).
- **κ** (*only for information*)
  isentropic exponent
- **Cp/Cv** (*only for information – AGA10 and AGA8:2017 only*)
  real gas specific heat ratio between

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– the specific heat capacity at a constant pressure c_p
– the specific heat capacity at a constant volume c_v

Parameterize the VOS comparison in Station AFB (⇨ volume “Station AFB” of the enCore FC1 manual).

User-defined display of the VOS calculations

By default the results of the calculated velocity of sound according are *not* shown in the displays of the Gas Quality AFB, since the export values are primarily used as input values for the VOS comparison of the Station AFB.

If necessary, extend the standard display of the Gas Quality AFB in the display editor. You reach the display editor in an open parameterization in enSuite by opening the branch **Displays – [<Group> –] <Gas Quality AFB>**.

2.5 Functioning at a Glance

2.5.1 Flowchart

Concludingly the interaction of the functional areas and selected parameters are represented in the following flowchart:

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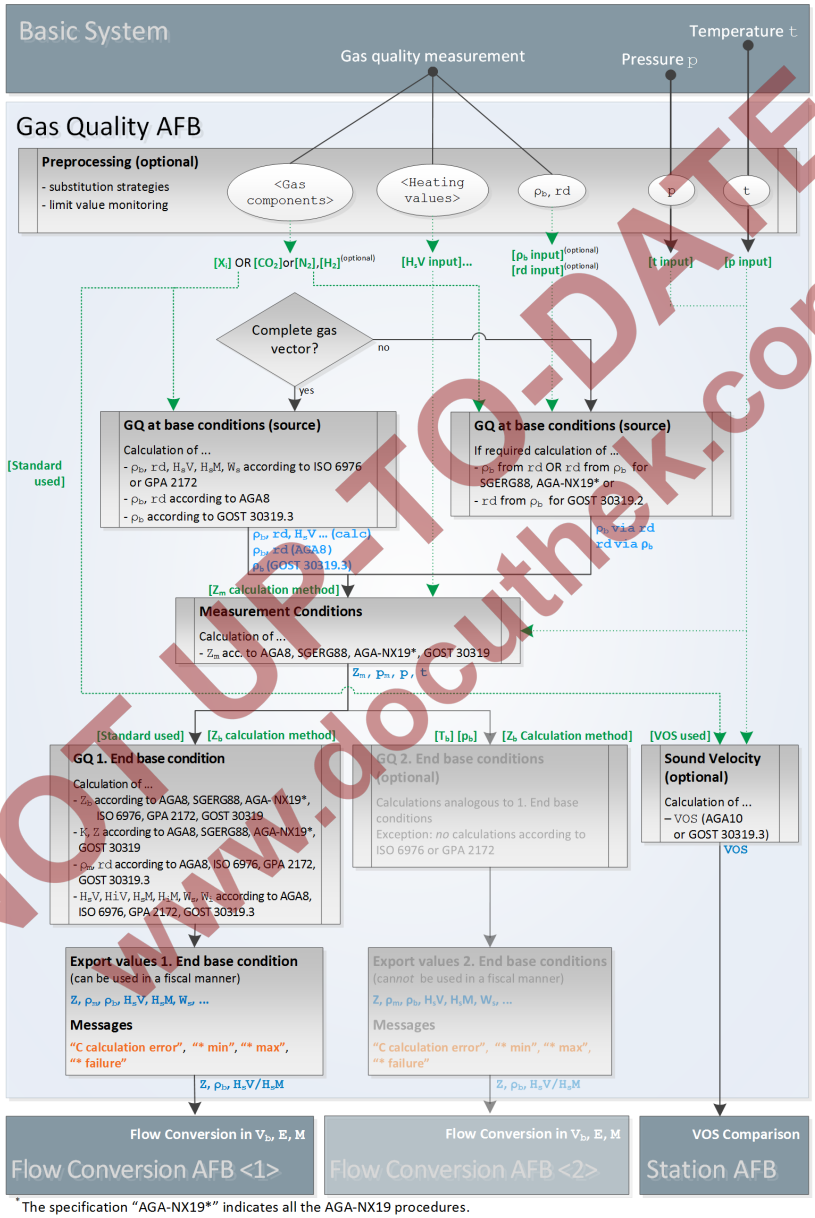

The specification "AGA-NX19" indicates all the AGA-NX19 procedures.

Fig. 2-2: Functional areas at a glance

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2.6 Warnings and Alarms

The enCore FC1 manages the warning and alarm messages of preprocessings and of the Gas Quality AFB in the error list and records it in the logbook.

2.6.1 List of Warnings and Alarms of Preprocessing Operations

Relevant warning and alarm messages are generated in case of an error depending on definitions of a single preprocessing or a preprocessing group:

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Identifier	Type	Cause
`Warning Level 1` up to `Warning Level 6`	Warning	• A warning limit (**Lower warning limit/ Upper warning limit**) of **Level <x>** is violated (limit monitoring). Additionally, the parameterized **Alarm behavior** determines whether or not a warning is generated for an erroneous level. The following settings for the **Alarm behavior** affect warning generation: • **non-sensitive** A warning is only generated for every erroneous level as long as *not all* levels are erroneous. However, alarms are generated as soon as all levels are erroneous (see below). • **deactivated** A warning is generated for every erroneous level.
`Alarm Level 1` up to `Alarm Level 6`	Alarm	The parameterized **Alarm behavior** defines the conditions under which an alarm is generated for an erroneous level. • **non-sensitive** An alarm is generated for erroneous levels only if *all* the defined Levels 1 to 6 are erroneous. • **sensitive** An alarm is generated for every erroneous level.

Tabelle 2-1: Warning and alarm messages of preprocessing operations

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2.6.2 List of Error Messages of the Gas Quality AFB

Depending on the parameterization the Gas Quality AFB monitors the input measurements and generates specific alarm messages in case of an error.

Limit monitoring only in case of preprocessing operations

Note that the lower and upper limits are monitored for input values only, for which the warning and/or alarm limits have been defined in a preprocessing of a Gas Quality AFB.

⇨ chapter 2.1.2 Monitoring Warning and Alarm Limits (Optional (p. 16)

Alarms for input values

Erroneous values are internally marked with a three-digit error code (⇨ appendix 5.3 Three-digit Error Code, p. 71). As soon as an input value is required for the calculations – such as pressure `p` and temperature `t` – the relevant alarm is generated on the basis of the error code.

- Minimum alarm (`* min`)
  … is triggered if the input fell below the lower limit.
  (Error code `OLL`)
- Maximum alarm (`* max`)
  … is triggered if the input exceeded the upper limit .
  (Error code `OUL`)
- Failure alarm (`* failure`)
  ... is triggered if the value is erroneous due to other reasons.
  (Error code e.g. `OOO`, `OOS`)

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	Identifier	Type	Cause
pressure p	p min	Alarm	The input for pressure p *fell below* the lower limit.
	p max	Alarm	The input for pressure p *exceeded* the upper limit.
	p failure	Alarm	The input for pressure p is erroneous.
temperature t	t min	Alarm	The input for temperature t *fell below* the lower limit.
	t max	Alarm	The input for temperature t *exceeded* the upper limitt.
	t failure	Alarm	The input for temperature t is erroneous.
C calculation	C calculation error	Alarm	The parameterized **Z_m calculation method** and/or **Z_b calculation method** cannot be carried out (e.g. as a result of inconsistent input values). Instead, the parameterized value **Z_m/Z_b Substitute value** is used for calculating C.
Gross volume-based	H_sV min	Alarm	The heating value H_sV is required for the parameterized calculation method, however, the input *fell below* the lower limit.

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	Identifier	Type	Cause
	H_sV max	Alarm	The heating value H_sV is required for the parameterized calculation method, however, the input *exceeded* the upper limit.
	H_sV failure	Alarm	The input for the upper volume-based heating value H_sV is erroneous, hence, no measured value is available.
Density at base conditions ρ_b	ρ_b min	Alarm	The input for density at base conditions ρ_b *fell below* the lower limit.
	ρ_b max	Alarm	The input for density at base conditions ρ_b *exceeded* the upper limit.
	ρ_b failure	Alarm	The input for density at base conditions ρ_b is erroneous, hence, no measured value is available.
relative density rd	rd min	Alarm	The input for the relative density rd *fell below* the lower limit.
	rd max	Alarm	The input for the relative density rd *exceeded* the upper limit.
	rd failure	Alarm	The input for the relative density rd is erroneous, hence, no measured value is available.
gas components	GQ failure	Alarm	The input value of any gas component is required for the parameterized methods **Z_m calculation method** and/or **Z_b calculation method**, but is erroneous.
	<component> min	Alarm	The respective gas component is required for the parameterized methods **Z_m calculation method** and/or **Z_b calculation method**, however, its input *fell below* the lower limit.

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	Identifier	Type	Cause
	`<component> max`	Alarm	The respective gas component is required for the parameterized methods **Z_mCalculation method** and/or **Z_bCalculation method**, however, its input *exceeded* the upper limit.

Table 2-2: Gas Quality AFB alarm messages

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3 Display and Operation

The Gas Quality AFB has various default displays which show important values such as pressure, temperature, compressibility, heating values and individual gas components.

Display and navigation in enCore devices

The general layout of displays for enCore devices and the basic navigation options are documented in detail in the “Operating Instructions” of the enCore FC1 manual in chapter for display and navigation.

Generally, hyperlinks and actions are distinguished during the device operation – both are shown with blue underline on the device and in the manual. Navigate through the device displays using hyperlinks; carry out a specific functionality with actions.

A list of symbols and names shown below is available in the appendix (⇨ appendix 5.1 Nomenclature, p. 64).

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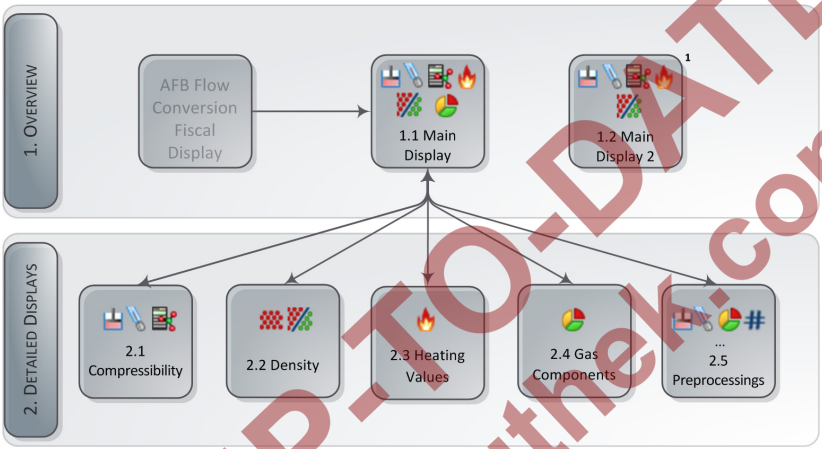
3.1 Displays at a Glance

The following figure sketches the hierarchical order and the navigation through the displays of the Gas Quality AFB:



[1] Navigation to **Main Display 2** is not set up by default, it is required only if you set up a **2nd end base condition**. In this case, you need to define a linkage point in the display editor.

Fig. 3-1: Display – hierarchical structure

3.2 Displays in Detail

The first display of every Gas Quality AFB is the main display.

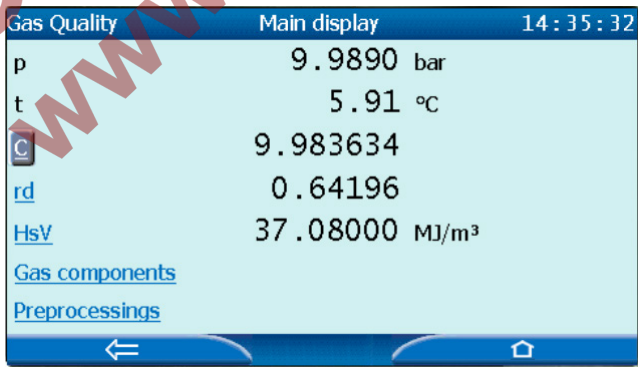


Fig. 3-2: Main display – example

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The most important measurements and results of the gas quality are presented in an overview in the main display. From this display you can switch to the detailed displays for compressibility, density, heating value, gas components and preprocessings.

Display editor of enSuite

This documentation describes the layout of individual displays in the delivery status.

You can adapt and configure most of the displays as per your needs with the help of the display editor of enSuite; you can define the values to be displayed and their displayed order.

The **Main display 2** is predefined, but not displayed by default. If you use the second end base conditions (section **2nd end base conditions**), then you can determine the navigation to **Main display 2** in the display editor.
⇨ FAQ 4.7 Calling up the Main Display 2 for the Second End Base Conditions (p. 62)

You reach the display editor in an open parameterization in enSuite by opening the branch **Displays – [<Group> –] <Gas Quality AFB>**.

How the displays are linked and the displayed values are described in the following tables:

⇨ The main display and its target displays (p. 48)
⇨ The Main display 2 (optional for 2nd end base conditions) (p. 51)

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The main display and its target displays

Main display		⇨ [<Target display>]
p	pressure at measurement conditions	/
t	temperature at measurement conditions	/
C	conversion factor	⇨ 2.1 **Compressibility** **p** pressure at measurement conditions **t** temperature at measurement conditions **C** conversion factor compressibility factor … **Z_m** … at measurement conditions **Z_b** … at base conditions **K** K factor compressibility factor … **$Z_{b\ air}$** … of air (at base conditions)
rd	relative density	⇨ 2.3 **Density** **ρ_m** density at measurement conditions **ρ_b** density at base conditions **$\rho_{b\ air}$** density of air at base conditions **rd** relative density
H_sV	heating value based on volume	⇨ 2.3 **Heating value** volume-based heating value… **H_sV** … – gross **H_iV** … – net mass-based heating value… **H_sM** … – gross **H_iM** … – net Wobbe index… **W_s** … – gross **W_i** … – net
Gas components		⇨ 2.4 **Gas components** gas vector with 22 components: **N_2** nitrogen **CO_2** carbon dioxide

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Main display	⇨ [<Target display>]
	CH_4 methane **C_2H_6** ethane **C_3H_8** propane **iso-C_4H_{10}** isobutane **n-C_4H_{10}** n-butane **iso-C_5H_{12}** isopentane **n-C_5H_{12}** n-pentane **neo-C_5H_{12}** neopentane **C_6H_{14}** hexane **C_7H_{16}** heptane **C_8H_{18}** octane **C_9H_{20}** nonane **$C_{10}H_{22}$** decane **H_2** hydrogen **O_2** oxygen **H_2O** water **H_2S** hydrogen sulphide **CO** carbon monoxide **He** helium **Ar** argon
Preprocessings[4]	⇨ 2.5 **Preprocessings** (⇨ section The display Preprocessings in detail, p. 50) drop-down list**<[(G)] preprocessing>** **Level 1** <measurement 1>[**A**] [<error code>] **Level 2** <if applic.[5] measurement 2>[sts[6] **in use**] **Level 3** <if applic. measurement 3> **Level 4** <if applic. measurement 4> **Level 5** <if applic. measurement 5> **Level 6** <if applic. measurement 6> **Level 7** <parameterized keypad value>

Table 3-1: The main display and its target displays

[4] The entry **Preprocessings** is displayed only if preprocessings are used.

[5] abbreviation for applicable

[6] abbreviation for status

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The display **Preprocessings** in detail:

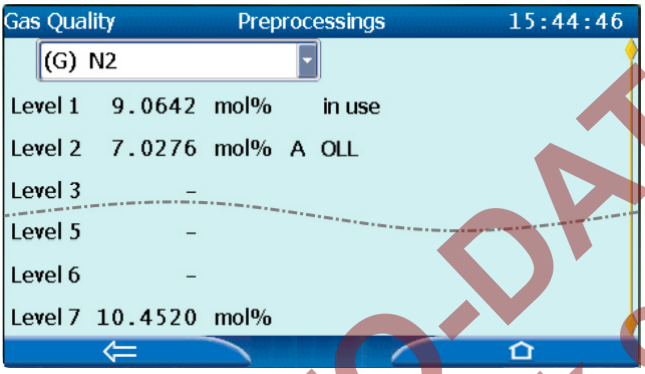

Fig. 3-3: Preprocessing – example

The individual preprocessings, which belong to the preprocessing groups, are marked in the drop-down list with a **(G)**.

The current (measurement) values are displayed for every defined level. The status **in use** signals that the (measured) value of this level makes available the preprocessing result. Levels which trigger an alarm are marked with an **A** (≙**A**larm), and levels which trigger a warning are marked with a **W** (≙**W**arning).

A three-digit identifier indicates the type of error in case of erroneous measurement. The measurement of **Level 2** as shown in the example is marked with **OLL** ("**O**ut of **L**ower **L**imit") because it has fallen below the parameterized lower alarm limit. (⇨ appendix 5.3 Three-digit Error Code, p. 71).

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The Main display 2 (optional for 2nd end base conditions)

Display	⇨ [<Target display>]
(configured linkage in the display editor)	⇨ 1.2 **Main display 2**[7] **p** pressure at measurement conditions **t** temperature at measurement conditions **C** conversion factor **rd** relative density **H_sV** gross volume-based heating value

Table 3-2: Main display 2 (optional)

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[7] The calculated values of **Main display 2** refer to the base conditions, which are parameterized in branch **2nd end base conditions** for temperature t_b and pressure p_b.

4 FAQ

This chapter contains the most important settings and issues in order to support you in regular tasks:

- ⇨ 4.1 The Alarm Behavior of Preprocessings – an Example (p. 52)
- ⇨ 4.2 Split up the Input Value for Hexane (C6H14) in Percentage for all the Higher Hydrocarbons (p. 55)
- ⇨ 4.3 For a Better Understanding: Base Conditions for Calculating Heating Value and Density at Base Conditions (p. 57)
- ⇨ 4.4 Differences between ISO 6976:1995 and ISO 6976:2016 (S. 59)
- ⇨ 4.5 Display Error Messages (p. 60)
- ⇨ 4.6 Accepting Warning and Alarm Messages (p. 61)
- ⇨ 4.7 Calling up the Main Display 2 for the Second End Base Conditions (p. 62)

4.1 The Alarm Behavior of Preprocessings – an Example

Background

The functioning of a multi-level substitution strategy is explained below using the example of three pressure transmitters. Limit monitoring is not parameterized in the example given below and the **Keypad value** is selected as **Substitute value mode**.

Alarm Behavior

The following settings are parameterized as an example – the different sensitivity levels of the alarm behavior are explained below:

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Parameter	Sample value
Physical quantity	absolute pressure
Level 1	tab **Export value**, branch **Basic System – I/O boards – Board 1: ExFME5 – P+ P−** **Measured value**
Level 2	tab **Export value**, branch **Basic System – I/O boards – Board 2: ExFME5 – P+ P−** **Measured value**
Level 3	tab **Export value**, branch **Basic System – I/O boards – Board 3: ExFME5 – P+ P−** **Measured value**
Keypad value	9.8 bar
Substitute value mode	**Keypad value**

Table 4-1: Preprocessings with the help of an example of three pressure transmitters

The preprocessing generates its result based on this parameterization – independent of the selected **Alarm behavior** – as given below:

- As long as the value from **Level 1** is considered error-free, it is used as the preprocessing result.
  As soon as this value is erroneous and as long as the value of **Level 2** is error-free, the measurement of **Level 2** is used.
  As soon the value in **Level 1** is no longer erroneous, this higher prioritized value is used again.
- If both measurements of **Level 1** and **Level 2** are erroneous, then the measurement of **Level 3** is used, as long as this value is error-free and the values of both the first levels are erroneous.
- If all measurements of **Level 1** up to **Level 3** are erroneous, then the preprocessing result is the parameterized **Keypad value**, until a valid measurement is provided again of **Level 1** up to **Level 3**.

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Use the parameter **Alarm behavior** to define the extent of sensitivity by which the preprocessing reacts to erroneous measurements and generates warning or alarms messages:

► Select the setting **sensitive** in order to generate an alarm for each error.

An alarm is generated for the respective level as soon as a measurement of **Level 1** to **Level 3** is erroneous. The preprocessing result is then considered to be erroneous, even if the preprocessing result is taken from a level whose measurement is error-free.

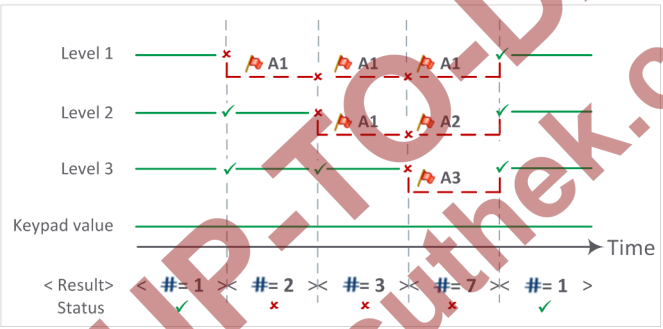

Fig. 4-1: Alarm behavior when **Alarm behavior**: **sensitive**

► Select the option **non-sensitive** in order to generate alarms only if there is *absolutely no* error-free measurement.

A warning is generated for the respective level as soon as a measurement for **Level 1** to **Level 3** is erroneous. The preprocessing result is considered error-free as long as not all the measurements of the three levels are erroneous.

An alarm is generated for each level if all the three measurements are erroneous. In this case, the preprocessing result is considered erroneous.

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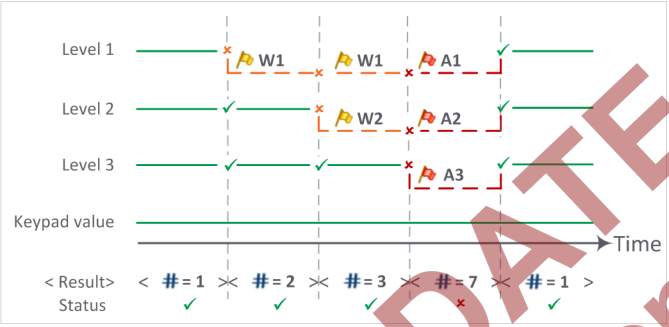

Fig. 4-2: Alarm behavior when **Alarm behavior**: **non-sensitive**

► Select the setting **deactivated** if there is *absolutely no* alarm to be generated.

A warning is generated for each of these levels as soon as at least one or all the measurements of **Level 1** to **Level 3** are erroneous. The result of the preprocessing is considered to be error-free.

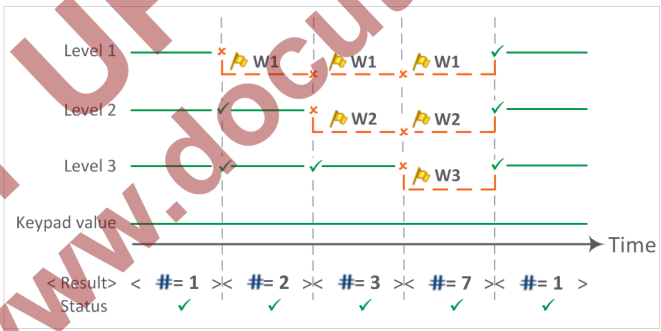

Fig. 4-3: Alarm behavior when **Alarm behavior**: **deactivated**

4.2 Split up the Input Value for Hexane (C_6H_{14}) in Percentage for all the Higher Hydrocarbons

Background

A few process gas chromatographs measure all the higher hydrocarbons from C_6 and above together and provide this sum as component hexane

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(C_6H_{14}). In such a case, you can split up the (C_6H_{14}) percentage arithmetically as C_6 to C_{10} in enSuite.

Procedure

The parameterization is possible only in the detailed view (on tab **Parameters**).

► Open the desired parameterization in enSuite.
► Go to the branch **<Gas Quality AFB> – Gas components**.
► On tab **Parameters** go to section **C_6H_{14}**.
► Select the desired entry from the drop-down list **Components treatment**.

- **No splitting** (*default*)
  The value of the components (C_6H_{14}) in the parameter **Input** is exclusively interpreted as component **C_6H_{14}**.
- **C_6+ split from C_6 to C_{10}**
  The value of the components (C_6H_{14}) in the parameter **Input** is distributed in percentage in higher hydrocarbons C_6 to C_{10}.

► If you have selected the entry **C_6+ split from C_6 to C_{10}**, enter the percentage for each component in the following parameters; note that all parts must add up to 100%:

- **C_6 %** percentage of hexane (C_6H_{14})
- **C_7 %** percentage of heptane (C_7H_{16})
- **C_8 %** percentage of octane (C_8H_{18})
- **C_9 %** percentage of nonane (C_9H_{20})
- **C_{10} %** percentage of decane ($C_{10}H_{22}$)

Depending on your choice either only the incoming value for hexane (C_6H_{14}) is used, or the arithmetically distributed values are used for all the further calculations.

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4.3 For a Better Understanding: Base Conditions for Calculating Heating Value and Density at Base Conditions

The Gas Quality AFB can calculate condition-dependent measurands such as heating value and density at base conditions on the bases of a complete gas vector. If the gas quality measurement device itself calculates the heating value and the density at base conditions, the enCore FC1 can import these values.

Heating values and density at base conditions are condition-dependent values and therefore based on specific base conditions (p_b, t_b); the heating value additionally depends on the notationally combustion conditions ($p_{comb.}$, $t_{comb.}$). This means that the base conditions of heating values and base density can be characterized completely by these four specifications.

enCore FC1 supports the international standards ISO 6976 and GPA 2172 while calculating the heating values and density at base conditions. Both the procedures take into consideration four variables (p_b, t_b, $p_{comb.}$, $t_{comb.}$) in a different way:

- ISO 6976

  ISO 6976 distinguishes between the combustion temperature and the temperature while measuring the volume; combustion pressure $t_{comb.}$ and pressure at base conditions p_b is defined at 1.01325 bar.

  The following base conditions are defined in the ISO:1995 and ISO 6976:2016,

  [($t_{comb.}$, t_n) °C, p_n bar]

  - (0, 0) °C, 1.01325 bar
  - (15, 0) °C, 1.01325 bar
  - (15, 15) °C, 1.01325 bar
  - (15,15; 15,55) °C, 1,01325 bar (only *ISO 6976:2016*)
  - (20, 20) °C, 1.01325 bar
  - (25, 0) °C, 1.01325 bar
  - (25, 20) °C, 1.01325 bar

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- **60 °F, <pressure at base conditions p_b> (GPA)**

  The GPA 2172 does not distinguish between combustion state and conditions when measuring volume. The temperature at base conditions t_b is defined as 60 °F; the pressure at base conditions p_b varies.
  The following base conditions are defined in the GPA,
  [t_n°F, p_n psia]
  - 60 °F, 14.696 psia
  - 60 °F, 14.65 psia
  - 60 °F, 14.73 psia
  - 60 °F, 15.025 psia

Since the values of the gas quality measurement device, may refer to other base conditions than the enCore FC1 calculations, the Gas Quality AFB takes into consideration two base conditions by default within the parameterization:

- base conditions of gas quality measurement device (≙ source) (section **Base conditions GQ source**, parameter **Standard used**)
- base conditions of enCore FC1 (≙ end) (section **End base conditions**, parameter **Standard used**)

The parameterization ensures that the selected base conditions are in agreement with the selected standard and thus the condition-dependent measurands can be calculated precisely.

Before the enCore FC1 can use the condition-dependent input values of gas quality measurement device, it has to check whether these refer to the end base conditions of enCore FC1. If this is not the case, it converts the values from base conditions of the source to end base conditions of the enCore FC1.

Special case: Second end base conditions for the enCore FC1

You can define second end base condition for enCore FC1 within the Gas Quality AFB (section **2nd end base conditions**). These base conditions (t_b, p_b) can be parameterized freely.

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With this, you can simultaneously calculate and view specific results such as heating values, base density and base volume at different base conditions. The results of the second end base conditions cannot be used for fiscal purposes because the calculations can be based on any desired base conditions.

⇨ section Parameterizing base conditions of enCore FC1 in enSuite (p. 33)

4.4 Differences between ISO 6976:1995 and ISO 6976:2016

Background

Since AFB version 03-13 the Gas Quality AFB supports the standard ISO 6976:2016. The standards ISO 6976:1995 and ISO 6976:2016 comply to a large extent. When this manual refers generally to the ISO 6976 standard, both versions of this standard are meant. Special features of a dated standard are marked with the year, i.e. as ISO 6976:1995 or ISO 6976:2016.

Main differences

- ISO 6976:1995 and ISO 6976:2016 use different sum factors for gas components of natural gas to calculate the real gas factor Z_b.
- ISO 6976:2016 provides for an additional combustion reference temperature at 15.55 °C (60 °F) in addition to 0 °C, 15 °C, 20 °C and 25 °C so that an additional combination of standard conditions for GQ source and end base conditions can be selected: (15.15; 15.55) °C, 1.01325 bar (ISO 6976:2016)
- The values for the molar mass of natural gas components were updated in ISO 6976:2016, as were the calorific values (on a molar basis) of natural gas components under various combustion reference conditions.
- The general gas constant has been changed:
  - ISO 6976:1995: R = 8.31451 Jmol-1K-1
  - ISO 6976:2016: R = 8.3144621 Jmol-1K-1

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4.5 Display Error Messages

Background

If the status LED is flashing yellow or red, or has continuous yellow or red light, there are warning and/or the alarm messages in the error list. In this list, the device manages events of type signal and type message of the Basic System and all AFBs.

The error list is sorted chronologically; the most recent message is displayed as first. You can specifically filter the entire list, e.g. as per the desired Gas Quality AFB. The preprocessing messages of the Gas Quality AFB are managed together with the AFB.

Procedure

► You reach the error list in the home display via the symbol **Error List**.

✓ The error list shows all the current warning or alarm messages.

You have different options:

► If only few errors are included in the entire list, scroll specifically for Gas Quality AFB messages.

Naming convention of error messages

AFB messages follow the naming convention:
[<Group>.]<Gas Quality AFB>.<message>

► In order to specifically filter messages of an Gas Quality AFB, select the entry **<Gas Quality AFB>** from the drop-down list **Filter**.

✓ Only messages of the corresponding Gas Quality AFB are displayed.

► In order to specifically filter messages of a Gas Quality AFB, which are grouped with other AFBs, select the **<Group>** from the drop-down list **Filter**.

✓ All the messages of AFBs which are assigned to this group are displayed.

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⇨ The next section describes the way you can accept Gas Quality AFB errors.

4.6 Accepting Warning and Alarm Messages

Background

Define the acceptance procedure with the parameter **Acceptance procedure** (branch **Basic System – System**, section **Error List**). This parameter determines if errors can only be accepted when they have already ended or if errors can always be accepted – irrespective of whether or not they are still.
Errors are accepted list-wise and not individually.

Details on the acceptance procedure are available in the online help.

For additional information on parameterization of acceptance behavior refer to ⇨ the “Operating Instructions” of the enCore FC1.

Procedure

- ► Open the error list as described in appendix 4.4 Differences between ISO 6976:1995 and ISO 6976:2016 (p. 59).
- ► In order to accept messages of a specific list, open it by selecting the corresponding entry **<Gas Quality AFB>** or **<Group>** from the drop-down list **Filter**.
- ► Trigger the action **Accept all**.
- ✓ The selected list is accepted and updated according to the parameterized acceptance procedure.

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► If required, repeat these steps for other lists.

4.7 Calling up the **Main Display 2** for the Second End Base Conditions

Background

If you use the second end base conditions (section **2nd end base conditions**), then you cannot view the values of the second end base conditions on the device display without further actions. The **Main display 2** is already created in enSuite, however, it is not linked with any other display by default, such that it cannot be called or displayed.
In this case, you must define the way to navigate to **Main display 2** in enSuite.

Procedure

► Open the desired parameterization in enSuite.
► In the parameter branch open the node **Displays**.
► Go to the branch and the display, from which the navigation of the second end base conditions shall be done, e.g. **<device> – <Gas Quality AFB> – Main display**.
✓ The current actions and values of the selected displays are listed on the tab **Display editor**. The positions of the individual entries comply with the displayed sequence in the enCore FC1.
► Click the plus sign in order to make another entry.
✓ A blank line is added to the list.

In order to link the Main display 2 with this display, …

► … enter the name of the hyperlink in the field **Caption** in the lower section of the tab, z.B. **Main display 2**.
► Select the entry **<Gas Quality AFB>** from the drop-down list **Link**.
✓ The second drop-down list is preset with the display types of the selected link **<Gas Quality AFB>**.

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- ► Select the entry **<Main display 2>**.
- ► If required, you can change the position of the hyperlink with the help of arrow keys.
- The **Main display 2** is linked to this display and can be called at the stated position via the hyperlink **<selected caption>**.

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5 Appendix

5.1 Nomenclature

The following symbols and names are used in the context of Gas Quality AFB:

Symbol	Abbreviated as	Description
	X_i	complete and normalized gas vector
	$X_{<CO2>}$	fraction of gas component, e.g. the CO_2 percentage
Preprocessing (folder **Preprocessings**/**Preprocessing group**)		
<sym.>	value	preprocessing result The corresponding symbol is displayed depending on the parameterized physical quantity. The following values are important for the Gas Quality AFB:
	value	• pressure p ⇨ import value for the section **Measurement conditions**, parameter **p input**
	value	• temperature t ⇨ import value for section **Measurement conditions**, parameter **t input**
	value	• molar fraction <chemical molecular formula>, e.g. N_2, CO_2 ⇨ import value for folder **Gas components**
#	<digit>	indication of the level that provides the preprocessing result. Value range: **1** to **7** (**Level 1** up to **Level 6**, **7** ≙ **Keypad value**)
Base conditions of the GQ source (according to ISO 6976/GPA 2172)		
	$\rho_{b\ calc.}$	density at base conditions
	$rd_{calc.}$	relative density

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	H_sV calc.	gross volume-based heating value
	H_iV calc.	net volume-based heating value
	H_sM calc.	gross mass-based heating value
	H_iM calc.	net mass-based heating value
	W_s calc.	gross Wobbe index
	W_i calc.	net Wobbe index
Base conditions of the GQ source (according to AGA8-DC92 or AGA8:2017)		
	Z_b AGA8	compressibility factor (end base conditions)
	ρ_b AGA8	density at base conditions
	rd AGA8	relative density
Base conditions GQ source – density		
	ρ_b via rd	density at base conditions Calculation based on the input value for the relative density rd (folder **Base conditions GQ source**, section **Density**, parameter **rd input**) and the density of air $\rho_{b\,air}$ at base conditions.
	rd via ρ_b	relative density Calculation based on the input value for the density ρ_b at base conditions (folder **Base conditions GQ source**, section **Density**, parameter **pb input**) and the density of air $\rho_{b\,air}$ at base conditions.
Measurement conditions		
	p	the current measurement for pressure p (ideally the result of the preprocessing) The Gas Quality AFB uses this measurement for its calculations. ⇨ 2.1 Defining Measurement Monitoring and Substitution Strategy (Preprocessing) (p. 9)

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	t	the current measurement for temperature t (ideally the result of the preprocessing) The Gas Quality AFB uses this measurement for its calculations. ⇨ 2.1 Defining Measurement Monitoring and Substitution Strategy (Preprocessing) (p. 9)
	Z_m	the calculated compressibility factor at measurement conditions The Gas Quality AFB calculates this value based on the **Z_m Calculation method**.
	ρ_m	density at measurement conditions
End base conditions		
	C	conversion factor (abbreviated as: C factor) ⇨ import value for the Flow Conversion AFB (section **Calculations**, parameter **C input**)
	ρ_b	density at base conditions
	rd	relative density
	H_sV	gross heating value based on volume
	H_iV	net heating value based on volume
	H_sM	gross heating value based on mass
	H_iM	net heating value based on mass
	W_s	gross Wobbe index
	W_i	net Wobbe index
	p_b	pressure at base conditions (end base conditions) (≙ pressure specification at base conditions of the parameter **Standard used**)
	t_b	temperature at base conditions (end conditions) (≙ temperature specification at base conditions of the parameter **Standard used**)

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	K	compressibility ratio(abbreviated K factor) intermediary result for calculating the conversion factor C
	Z_b	compressibility factor at base conditions Intermediary result for calculating the K factor K and the conversion factor C Hint for the second end base conditions: If Z_b has to be calculated according to ISO 6976 or GPA 2172, but the parameterized second base conditions does not correspond to the correspon-ding standard, then Z_b is calculated according to AGA8-DC92 or AGA8:2017.
	$Z_{b\,air}$	compressibility factor of air at base conditions Hint for the second base conditions: If the parameterized second end base conditions correspond to one of the combinations listed under ISO 6976, then the value for $Z_{b\,air}$ is taken from ISO 6976. Otherwise, $Z_{b\,air}$ is calculated using AGA8 and is based on the air composition, as stated under ISO 6976.
	$\rho_{b\,air}$	density of air at base conditions
Molar mass		
	M_{air}	molar mass of air (constant value) tabular value according to... • ISO 6976:1995: 28.9626 kg/kmol • ISO 6976:2016: 28,96546 kg/kmol
	M_{gas}	molar mass of natural gas (calculated) M_{gas} is calculated on the basis of the complete gas composition according to ISO 6976 ; if no complete gas vector is available, then the M_{gas} is marked as unused.

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VOS		
	VOS	velocity of sound (calculated) The VOS calculations according to AGA10, AGA8:2017 or GOST 30319.3 are based on a normalized gas vector as well as the pressure p and the temperature t at measurement conditions. ⇨ import value for the Station AFB (section **VOS comparison**, parameter **Calculated VOS input**)
#	κ	isentropic exponent (intermediary result)
#	C_p/C_v	compressibility-specific thermal ratio (AGA10 and AGA8:2017 only) (intermediary result)

Table 5-1: Nomenclature

5.2 International Calculation Methods

5.2.1 Overview

The following table lists the international standards and calculation methods the Gas Quality AFB supports, as well as the necessary input values and their major results. Note that not all calculation methods are available in all device types:

Procedures	Required input values	Resulting value (Base conditions GQ source)	Resulting value (End base conditions)
$rd = \frac{\rho_b}{\rho b_{air}}$	ρ_b input rd input	rd via ρ_b ρ_b via rd	
AGA8-DC92	p, t, X_i	$Z_{b\ AGA8}$, $\rho_{b\ AGA8}$, rd_{AGA8}	Z_m, Z_b, K, C, ρ_b, rd
– VOS calculation used (AGA10)			VOS, κ, C_p/C_v
AGA8:2017	p, t, X_i	$Z_{b\ AGA8}$, $\rho_{b\ AGA8}$, rd_{AGA8}	Z_m, Z_b, K, C, ρ_b, rd

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– VOS calculation used			VOS, κ, C_p/C_v
ISO 6976, GPA 2172	p, t, X_i	$\rho_{b\ calc}$, rd_{calc}, H_sV_{calc}, H_iV_{calc}, H_sM_{calc}, H_iM_{calc}, $W_{s\ calc}$, $W_{i\ calc}$	Z_b, K, C, ρ_b, rd, H_sV, H_iV, H_sM, H_iM, W_s, W_i
SGERG-88	p, t plus depending on the SGERG variant: ρ_b, H_sV, X_{CO2}; ρ_b, H_sV, X_{N2}; ρ_b, H_sV, X_{CO2}, X_{H2}; ρ_b, H_sV, X_{N2}, X_{H2}; ρ_b, X_{N2}, X_{CO2}; rd, H_sV, X_{CO2}; rd, H_sV, X_{N2}; rd, H_sV, X_{CO2}, X_{H2}; rd, H_sV, X_{N2}, X_{H2}; rd, X_{N2}, X_{CO2}		Z_m, Z_b, K, C
AGA-NX19, AGA-NX19 BR. KORR.3H, AGA-NX19 GOST	p, t, rd, H_sV, X_{N2}, X_{CO2}		Z_m, Z_b, K, C
GOST 30319.2	p, t, X_{N2}, X_{CO2}		Z_m, Z_b, K, C
– VOS calculation used			VOS, κ
GOST 30319.3	p, t, X_i	$Z_{b\ GOST}$, $\rho_{b\ GOST}$	Z_m, Z_b, K, C, ρ_b
– VOS calculation used			VOS, κ

Table 5-2: Input values and results of calculation methods

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5.2.2 Required Input Values and their Parameterization

Procedures	Input values	Parameter
AGA8-DC92, AGA8:2017 ISO 6976, GPA 2172, GOST 30319.3	temperature t	section **Measurement conditions**, parameter **t input**
	pressure p	section **Measurement conditions**, parameter **p input**
	normalized gas vector X_i	folder **Gas components**, 22 components; GOST 30319.3 is using 15 components (A normalization procedure is carried out if the input vector is not normalized.)
SGERG88 variants	temperature t	section **Measurement conditions**, parameter **t input**
	pressure p	section **Measurement conditions**, parameter **p input**
	density at base conditions ρ_b	folder Base conditions **GQ source**, parameter **ρ_b input**
	relative density rd	folder **Base conditions GQ source**, parameter **rd input**
	heating value H_sV	folder Base **conditions GQ source**, parameter **H_sV input**
	nitrogen X_{N2}	folder **Gas components**, parameter **N_2**
	carbon dioxide X_{CO2}	folder **Gas components**, parameter **CO_2**
	hydrogen X_{H2}	folder **Gas components**, parameter **H_2**
AGA-NX19 variants	temperature t	section **Measurement conditions**, parameter **t input**
	pressure p	section **Measurement conditions**, parameter **p input**
	relative density rd	folder **Base conditions GQ source**, parameter **rd input**

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Procedures	Input values	Parameter
	heating value H_sV	folder **Base conditions GQ source**, parameter **H_sV Iinput**
	nitrogen X_{N2}	folder **Gas components**, parameter **N_2**
	carbon dioxide X_{CO2}	folder **Gas components**, parameter **CO_2**
GOST 30319.2	temperature t	section **Measurement conditions**, parameter **t input**
	pressure p	section **Measurement conditions**, parameter **p input**
	nitrogen X_{N2}	folder **Gas components**, parameter **N_2**
	carbon dioxide X_{CO2}	folder **Gas components**, parameter **CO_2**

Table 5-3: Calculation methods – input values and their parameters

5.3 Three-digit Error Code

Erroneous values are internally marked with a three-digit identifier. This reflects the error status of a value.

Within the **Preprocessings** display, the error code for the input values of individual levels are displayed in addition. Whether or not a preprocessing result has to be marked as erroneous depends on the error state of the individual levels as well as on the parameterized alarm behavior (⇨ 2.1.1 Substitution Values and Substitution Strategies, p. 10). If a preprocessing result is erroneous, then it has the same error code as the erroneous level having the highest priority.

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The following table lists all the error codes along with their meaning:

Error identifier	Meaning
INT	("**IN**i**T**ial") The value was not yet determined after the last start-up of the enCore device.
OOU	("**O**ut **O**f **U**se") The value is not used or not provided intentionally.
OOS	("**O**ut **O**f **S**ervice") An input value is marked invalid for further processing using the parameter **Out of Service** e.g. during maintenance works. Within a preprocessing operation, an OOS marked value is ignored; if possible, the preprocessing switches to a substitute level without any error message.
OOO	("**O**ut **O**f **O**rder") An input value is physically not provided available, for example due to a defective input board or a timeout/protocol error in case of digitally transmitted values.
OOC	("**O**ut **O**f **C**alculation") is set for calculated or derived values, if … • … a required input value is erroneous. • … an internal error is detected in the calculation routine, e.g. as a result of inconsistent input values. Exceptions for the Gas Quality AFB: If an input component is erroneous in case of a complete gas vector, then the complete output gas vector is marked as OOC.
OLL	("**O**ut of **L**ower **L**imit") An input value is available, but it violates the parameterized lower alarm limit (taking into consideration the parameterized **Hysteresis**).
OUL	("**O**ut of **U**pper **L**imit") An input value is available, but it violates the parameterized upper alarm limit (taking into consideration the parameterized **Hysteresis**).

Table 5-4: Gas Quality AFB error codes

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